CHAPTER 4

Rice Stand Establishment

Nathan Buehring, Tim Walker, and Jason Bond

Maximum rice yield begins with a sufficient stand of rice. Stand establishment is affected by many factors, including cultivar selection, seedling vigor, seeding date, seeding rate, seed treatments, environment, and geographic location. Uneven emergence results in an uneven rice crop. Management decisions may be difficult for the rest of the growing season because of the variety of growth stages. Uniform rice emergence is also important for accurate DD50 predictions of growth stages.

Seed Bed Preparation

A smooth, weed-free seedbed is a must for dry-seeding rice. In a continuous rice culture, the field should be disked or rolled in the fall to help start rice straw decomposition. There are several ways to remove and smooth the old levees in the field. Do this to get rid of potholes and rough areas in the field before disking. It takes less time to prepare land in a rice and soybean rotation because soybean harvest usually leaves the soil in good condition. This is especially common in an early soybean production system. For a smooth seedbed at planting in the spring, do most of the tillage operations in the fall with only minimal tillage in the spring before planting. Fall disking and light spring tillage provide the best seedbed for planting rice. If clods are a problem, use a drag pipe or corrugated roller to firm the seedbed. A fall or spring burndown herbicide application may be necessary to control winter weeds and eliminate another tillage operation. See the Rice Weed Control section for specific winter weed control recommendations. Always check herbicide labels for rotation restrictions with herbicides that have been applied to a specific field in previous crops. See Table 4.1 for herbicide rotation restrictions when planting rice.

Seeding Rate

Cultivars

Seeding rates for rice vary slightly among cultivars because of differences in seed weight and size. Table 4.2 lists the number of seed per square foot at specific seeding rates for common Mississippi cultivars. As a general rule, about 60 to 70 percent of the rice seed planted will germinate and emerge. The optimum stand density ranges from 12 to 20 plants per square foot. If carefully managed, a uniform stand of more than six plants per square foot can produce satisfactory yields. To achieve the optimum density, there are things to consider besides seeding rate. The following strategies also encourage optimum germination rates:

- Planting when the soil temperature averages 60 ˚F or greater
- Planting seed treated with fungicide, such as Apron XL LS
- Rolling to increase seed-to-soil contact
- Planting into a firm and smooth seed bed

Under optimal conditions, seeding rates as low as 40 pounds per acre can result in a sufficient plant population (more than 12 plants per square foot) with yields comparable to a seeding rate of 100 pounds per acre. Table 4.3 compares seeding rates and corresponding plant populations to yield among common rice cultivars. The table shows that a seeding rate of 40 pounds per acre can result in yields similar to 100 pounds per acre for each of the cultivars. It also shows that more than seven plants per square foot can produce rice yields comparable to the yields of higher plant populations. Lower seeding rates can work if the stand is uniform. The strategies mentioned increase the chances of a uniform stand. Here are some advantages to lower seeding rates:

- Seed Cost: Reducing seeding rates reduces seed cost, especially for hybrid cultivars. Most producers think a high seeding rate is a form of cheap “insurance.” But a high seeding rate of a Clearfield cultivar can be very costly. Reducing the seeding rate can reduce seed cost but maintain high yields.
- Disease Pressure: A lower seeding rate could reduce the potential for diseases such as sheath blight. Thinner stands can increase airflow through the canopy, which discourages diseases.
- Lodging Potential: A lower seeding rate could reduce the potential for lodging, especially with taller cultivars.

Table 4.1. Herbicides and Crop Rotation Restrictions

Herbicide Common Name	Trade Name	Rice Rotation Restriction
Atrazine	Aatrex (and many others)	Following year. If you apply after June 10, plant rice the second year.
Atrazine + Metolachlor	Bicep II Magnum	15 months
Chlorimuron	Classic	9 months
Clethodim	Select	30 days
Clomazone	Command	Less than 2 pts: anytime Greater than 2 pts: 9 months
Chloransulam	Frontrow	6 months
Dimethenamid	Outlook or Frontier	Following year
Diuron	Karmex (Many Others)	Following year
Fluazifop	Fusilade	60 days
Flumetsulam	Python	9 months
Fluometuron	Cotoran (Many Others)	6 months
Flumioxazin	Valor	0 - 2 oz: 30 days 2 - 3 oz: 2 months plus 1" of rainfall
Fomesafen	Reflex	10 months
Imazaquin	Scepter	Following year
Imazethapyr	Newpath	18 months
Metolaclor	Dual	Next spring
Metribuzin	Sencor/Lexone	8 months
Metribuzin + Chlorimuron	Canopy	pH less than 7.0: 10 months pH 7.1 to 7.5: 18 months
MSMA	Various Formulations	None, but take precautions for straighthead
Nicosulfuron	Accent	pH less than 6.5: 10 months pH greater than 6.5: 18 months
Oxyfluorfen	Delta Goal	10 months
Pendimethalin	Prowl, Pendimax	Following year
Primisulfuron	Beacon	18 months
Prometryn	Caparol	Following year
Pyrithiobac	Staple	9 months
Quizalofop	Assure II	120 days
Trifluralin	Treflan (Many Others)	Following year, 2 years for 2X rate
Trifloxysulfuron	Envoke	7 months
Trifloxysulfuron + Prometryn	Suprend	7 months

Table 4.2. Rice seeding chart for different rice cultivars and seeding rates								
		Seeding Rate (lbs/A)						
Variety	Seed/lb	50	60	70	80	90	100	110
		Number of Seed/ft²						
Bowman	17700	20	24	28	33	37	41	45
CL 131	19654	23	27	32	36	41	45	50
CL 161	20826	24	29	33	38	43	48	53
Cl 171-AR	19654	23	27	32	36	41	45	50
Cocodrie	18996	22	26	31	35	39	44	48
Cybonnet	18917	22	26	30	35	39	43	48
Sabine	18606	21	26	30	34	38	43	47
Trenasse	17804	20	25	29	33	37	41	45
Wells	17945	21	25	29	33	37	41	45

		Seeding Rate (lbs/A)			
Hybrid	Seed/lb	25	30	35	40
		Number of Seed/ft²			
XL 723	17262	10	12	14	16

Table 4.3. The influence of seeding rate on plant density and rough rice yield.								
Seeding Rate (lb/A)	Cocodrie		Francis		Priscilla		Wells	
	Density[a]	Yield[b]	Density[a]	Yield[b]	Density[a]	Yield[b]	Density[a]	Yield[b]
20	7	216	7	220	7	213	8	217
40	16	230	16	221	10	225	14	233
60	21	230	19	227	16	229	22	233
80	28	227	25	225	24	232	27	228
100	29	234	34	234	31	221	31	230

[a]**Plants/ft2**

[b]**Bushels/A**

Source: Bond et al. 2005. Seeding rates for stale seedbed rice production in midsouthern United States. Agron. J. 97:1560-1563.

There are some disadvantages to lower seeding rates. One disadvantage is that a lower seeding rate can reduce rice competition with weeds. This is a common problem with semi-dwarf cultivars because they already compete less than taller cultivars do. Thin stands of a semi-dwarf variety compete even less where weeds are dense.

Another disadvantage is increased rice water weevil pressure. As the rice stand density decreases, the likelihood of having problems with rice water weevils increases. If you use a low seeding rate, you may need to apply an insecticide at flooding.

Hybrids

Hybrid rice cultivars can be planted at a lower seeding rate than a conventional cultivar can be because hybrids can tiller profusely. A seeding rate of 30 to 35 pounds per acre generally results in an optimum stand density of 9 to 12 plants per square foot for hybrids. The key for successful hybrid production is uniform emergence and stand. If rice emergence is not uniform, the different levels of maturity can harm rice milling.

Getting a uniform stand can be difficult with hybrids, especially with these low seeding rates. Use suggestions listed earlier for optimum germination rates. Under very thin and nonuniform stands, replanting may be necessary. But plant stands of 3 plants per square foot can provide acceptable yields because hybrids have such a high tillering capacity. Table 4.2 lists the number of seed per square foot at specific seeding rates for common Mississippi hybrids.

Row Spacing

Rice is often planted with a grain drill at a row spacing of 6 to 10 inches. These row spacings can produce similar yields. However, narrower drill row spacings tend to produce higher yields. A drill spacing of 6 to 8 inches is best. When changing row spacings, seeding rates do not need to be adjusted. Table 4.4 provides the number of seed per foot for 6 to 10 inch drill row spacing and seeding rates for drill calibration.

Table 4.4. Seed Spacing for Calibrating Drills.

	Row Spacing				
Seed/ft^2	6"	7"	8"	9"	10"
	(Seed per row foot)				
10	5	6	7	8	8
15	8	9	10	11	13
20	10	12	13	15	17
25	13	15	17	19	21
30	15	17	20	23	25
35	18	21	23	26	29
40	20	23	27	30	33
45	23	26	30	34	38
50	25	29	33	38	42

Seed Treatments

Most seed dealers in Mississippi offer seed treatments on all grades of seed. Seed treatments are fairly inexpensive and can optimize germination rates. Fungicides and growth regulators are the most common seed treatments. Base seed treatment decisions on planting date, seedbed condition, cultivar, and field history.

Fungicide seed treatments are often helpful when rice is planted early, especially on clay soils. They are also beneficial if the field has a history of seedling diseases. If conditions promote fungi, a fungicide seed treatment can increase germination by 10 to 20 percent. Fungicide seed treatments do not increase the speed of germination like a growth regulator does or protect against diseases throughout the growing season. See Table 4.5 for registered seed treatments and their recommended rates, fungi they control, and application methods.

Today, the only recommended growth regulator seed treatment is gibberellic acid (GA). Seed treated with GA is recommended on semidwarf cultivars, cultivars with poor seedling vigor, clay soils, and rice planted early. GA-treated seed promotes uniform emergence and quick germination and emergence. Rice seedlings may appear tall and yellow after emergence when GA is used; these symptoms reduce in 1 to 2 weeks. Gibberellic acid does not protect the seed from any of the common seedling diseases. You may use fungicide with GA, but read label instructions before use.

Table 4.5. Recommended rice fungicide seed treatments				
Disease	Fungicide	Active Ingredient	Rate/cwt Seed	Comments
Pythium diseases	Allegiance FL (formerly Apron)	metalaxyl	0.75 - 1.5 fl oz	Apply with commercial seed-treating equipment.
	Apron XL LS	mefenoxam	0.32 - 0.64 fl oz	Apply with commercial seed-treating equipment. Use higher rates for early planting or other severe disease situations.
Rhizoctonia seedling diseases, general seed rots	RTU-Vitavax-Thiram	carboxin + thiram	6.8 fl oz	Apply with commercial seed-treating equipment or use as a pour-on hopper-box treatment.
	Vitavax 200	carboxin + thiram	4 fl oz	Apply with commercial seed-treating equipment.
	Maxim 4 FS	fludioxonil	0.08 - 0.16 fl oz	Apply with commercial seed-treating equipment. Use higher rates for severe disease.
	Trilex FL	trifloxystrobin	0.32 - 0.64 fl oz	Apply with commercial seed-treating equipment.
	Dynasty	azoxystrobin	0.153 - 1.53 fl oz	Apply with commercial seed-treating equipment.
Pythium, Rhizoctonia, general seed rots	Vitavax 200 + Allegiance FL (formerly Apron)	carboxin + thiram + metalaxy	4 fl oz + 0.375 fl oz	Apply with commercial seed-treating equipment.
	Apron XL LS + Maxim 4 FS	mefenoxam + fludioxonil	0.32 - 0.64 fl oz + 0.08 - 0.16 fl oz	Apply with commercial seed-treating equipment. Use higher rates for early planting or severe disease.
	Stiletto	carboxin + thiram + metalaxyl	6.8 fl oz	Apply with commercial seed-treating equipment.
	Trilex FL + Allegiance FL	trifloxystrobin + metalaxyl	0.64 fl oz + 0.64 fl oz	Apply with commercial seed-treating equipment.

Seeding Date and Soil Temperature

Do not plant rice until the average 4-inch soil temperature is 60 ˚F. This normally occurs around April 1 in Stoneville and April 5 in Tunica. The higher the soil temperature, the less time seed takes to emerge. When the average soil temperature is 60 ˚F and there's enough moisture, rice should emerge in 2 to 3 weeks. Once the average soil temperature reaches 70 ˚F, the time between seeding and emergence should be 1 week. Production costs may increase because of flushing and weed control when rice is planted at a soil temperature lower than 70 ˚F.

Table 4.6 lists the optimum planting dates for rice cultivars commonly grown in Mississippi. In the southern Delta, the best time to plant rice is from April 1 to about May 20, depending on the cultivar. In the northern

Delta, the best time is from April 5 to May 15. These dates are based on averages and may change based on the weather during planting season.

Rice can be planted after wheat or fields that were precision graded in the spring. If you must plant rice in June, choose a cultivar that is suited for late planting. Studies in Mississippi show that Priscilla or any of the hybrids are suitable for late planting. Remember that rice planted in June usually has a lower yield potential than rice planted in April or May.

If you plant rice on a large acreage, consider using different cultivars and staggering the planting dates so that rice matures at different times and can be harvested as it matures. Table 4.7 estimates maturity for different emergence dates and rice cultivars.

Post Seeding Management

Rolling

Rolling behind drilled rice increases stand density because it increases seed-to-soil contact. If the soil is cloddy at planting, always use a roller behind the drill.

Levee Surveying and Construction

Generally, levees are surveyed on a contour at vertical intervals of 0.1 to 0.2 foot between levees. The vertical interval is usually 0.2 foot between levees. If a small acreage is on a steep slope (2 to 4 percent slope), either place levees at 0.3 to 0.4 foot vertical intervals or convert to another crop. When surveying, a shallow furrow is commonly made on a contour of the vertical intervals. The furrow acts as a guide for levee construction. The proper location of levees depends on the experience of the surveyor or operator and the accuracy of the instrument.

Where fields have been land formed for straight levees and the grade has been maintained, you can simply place levees with a measured distance between them.

Table 4.6. Optimum planting dates for selected cultivars that are commonly grown in Mississippi.

	South Delta		North Delta	
Cultivar	Optimum[a]	Cutoff	Optimum[a]	Cutoff
Bowman	April 1 - May 20	June 15	April 5 - May 15	June 10
CL 131	April 1 - May 15	June 10	April 5 - May 10	June 5
CL 161	April 1 - May 20	June 15	April 5 - May 15	June 10
CL 171-AR	April 1 - May 20	June 15	April 5 - May 15	June 10
Cocodrie	April 1 - May 15	June 10	April 5 - May 10	June 5
Cybonnet	April 1 - May 15	June 10	April 5 - May 10	June 5
Sabine	April 1 - May 15	June 10	April 5 - May 10	June 5
Trenasse	April 1 - May 15	June 10	April 5 - May 10	June 5
Wells	April 1 - May 20	June 15	April 5 - May 15	June 10
XL 723	April 1 - May 20	June 15	April 5 - May 20	June 15

[a]These suggested planting dates do not guarantee high yields or prevent a crop failure. Rice can be planted before April 1 but not before March 25 in the southern Delta region. Rice can be planted before April 5 but not before April 1 in the northern Delta region.

Table 4.7. The predicted maturity date as influenced by the emergence date and cultivar[a]						
	Rice Emergence Date					
Cultivar	April 15	April 25	May 5	May 15	May 25	June 5
	Predicted Maturity Date[b]					
Bowman	Aug. 20	Aug. 25	Aug. 30	Sept. 7	Sept. 16	Sept. 29
CL 131	Aug. 20	Aug. 25	Aug. 31	Sept. 7	Sept. 16	Sept. 29
CL 161	Aug. 22	Aug. 27	Sept. 3	Sept. 10	Sept. 19	Oct. 4
CL 171-AR	Aug. 19	Aug. 24	Aug. 30	Sept. 7	Sept. 16	Aug. 22
Cocodrie	Aug. 20	Aug. 25	Aug. 30	Sept. 7	Sept. 16	Sept. 29
Cybonnet	Aug. 19	Aug. 24	Aug. 30	Sept. 7	Sept. 15	Sept. 28
Sabine	Aug. 20	Aug. 25	Aug. 31	Sept. 7	Sept. 16	Sept. 29
Trenasse	Aug. 18	Aug. 23	Aug. 29	Sept. 6	Sept. 14	Sept. 27
Wells	Aug. 20	Aug. 26	Sept. 1	Sept. 8	Sept. 17	Sept. 30
XL 723	Aug. 21	Aug. 26	Sept. 1	Sept. 8	Sept. 17	Oct. 1

[a]Using weather norms from Stoneville, MS.

[b]Approximate date when rice will be at 20% moisture.

Levees must be well placed and well made to maintain a uniform water depth within each bay. In fields where levees run parallel to prevailing winds, build at least one wind levee at a right angle with the prevailing wind. Wind levees are especially important in a large bay. These levees are not tied into the perimeter or field levees. The purpose of the wind levee is to keep the wind from "stacking" the flood on one end of a large bay.

After planting dry seed, start levee construction over the contour furrow right away. Finish the operation as quickly as possible. If levee construction is delayed or prolonged rains occur after you make only one or two passes, construction will be very difficult. On heavy clay soils, you'll probably have to make four to five passes with a levee disk to reach the desired levee height of 20 to 24 inches.

You can compact the levee with tractor tires or a commercial levee packer. A levee should be compact and high enough to hold a 3- to 6-inch flood. Plan for the levee to settle after several rains.

On silt loam soils, levees should be seeded just before the final trip with the levee disk. On clay soils, levees should be seeded just after the last pass. Levees on clay soils should be packed with a spool-shaped levee packer before they are planted to keep seed from being placed too deep because of large loose clods. Levees are often seeded with a seeder mounted on the front of a tractor or above the levee plow, a pull-type grain drill, or a back-mounted seeder. The front-mounted seeder allows you to seed the levees and make the final pass with the levee disk at the same time.

After you've finished the field levees, build and seed the perimeter levee similarly. Join field levees with the perimeter levee about 7 to 10 days before an anticipated flooding. A backhoe or a small tractor with a blade does an excellent job.

CHAPTER 5

DD50 Rice Growth and Management Predictions

Nathan Buehring, Mark Silva, and Lyle Pringle

The DD50 program is a management tool developed by the National Weather Service to predict the development of the rice plant through its vegetative and reproductive stages. Weather information is collected on a daily basis across the state and tabulated by computer. The program is based on an accumulation of the high and low daily temperatures, with a base temperature of 50 °F. The following equation describes how DD50's are calculated:

$$DD50 = \frac{[\text{Daily Maximum} + \text{Minimum Temperature}] - 50}{2}$$

If maximum temperature is greater than 94 ˚F, use 94 for maximum temperature.

If minimum temperature is less than 70 ˚F, use 70 for minimum temperature.

You can find the DD50 program on the Mississippi State University Extension Service's website, **http://ext.msstate.edu/anr/drec/weather.cgi.** This will allow real-time weather and more accurate predictions.

To use the DD50 program, record the cultivar name and emergence date. The cultivar list changes each year as new varieties are released and older varieties are deleted. For the most accurate predictions, record the date of the following growth stages as they occur:

- Emergence
- First Tiller
- ½ Inch Internode or Panicle Differentiation
- 50 Percent Heading
- 100 Percent Heading

Once the rice reaches one of the progressive growth stages, update the date on the web site for a more accurate prediction. Because the interactive rice DD50 program uses real-time weather data, the DD50 predictions can be updated on a daily basis or when the rice advances to the next growth stage. See example printout on next page.

As a reminder, these are just predictions. Do not make pesticide or fertilizer applications based on these forecasted dates. Any kind of stress can increase or delay these dates. There is no substitute for monitoring rice fields in person.

Example of DD50 Information

Rice Growth and Management Predictions
Mississippi State University Extension Service

Variety: CL-161

County: Bolivar	**Grower: Nathan Buehring**
Field ID: 1	**Acreage: 40**
Year: 2006	**Report Date: Sep 16th, 2006**

Date	**Growth and Management Events**
05/01	Emergence - Average 10 one-leaf rice plants per square foot.
05/01 - 05/08	Apply Herbicide - Apply first post application of Newpath to spike to 1 leaf rice if not applied pre-emergence.
05/01 - 05/19	Flush Fields - May need to flush field.
05/01 - 05/19	Control Insects - Control Insects: A. Armyworms; or B. Chinch bugs (may be controlled by flooding or by applying insecticide).
05/19	Apply Fertilizer - Apply 115-120 lbs Nitrogen/Acre (250-261 lbs. Urea) on a dry soil surface.
05/19	First Tiller - Tillering begins.
05/19	Control Weeds - Control weeds (Apply second application of Newpath during the 3 to 5 leaf growth stage).
05/19	Flood - Apply shallow flood.
05/19 - 05/24	Check for Water Weevils - Scout for adult water weevils (apply insecticide if necessary) unless Icon seed treatment was used.
05/23 - 06/15	Apply Post-Flood Herbicide - Begin to apply if necessary (flood must be established and stable).
06/15 - 06/19	Apply Mid-Season Herbicide - Begin checking for green ring and internode elongation. Apply mid-season herbicides (if necessary).
06/19	½ Inch Internode - Apply 45-60 lbs Nitrogen (100-130 lbs. Urea).
06/21	Control Disease - Begin scouting for sheath blight. Apply fungicide at 35% positive infestation.
06/28	Early Boot - Apply recommended fungicide, if needed, for blast or sheath blight.
07/18	Boot Split - Stop scouting for sheath blight; continue scouting for blast.
07/20	10% Heading - Start checking for Stinkbug, Armyworm, & other insect infestations with a sweep net. Apply insecticide if needed.
07/23	50% Heading - Continue to check for stinkbugs.
07/25	70 to 80% HEADING - End blast scouting or apply recommended fungicide for blast.
07/27	100% Heading - Check again for stinkbug and other insect infestations.
08/22	Stop Pumping - Stop pumping (all heads turned down - upper ¼ - ⅓ heads are straw colored. Stop insect scouting if insects are not present).
08/24	Drain Fields - Drain fields (1. On clay soils - heads turned down - upper ½ head is straw colored; 2. On silt/sandy soils - heads turned down - upper ¾ head is straw colored).
09/02	Harvest - High yields demand slow harvest speed for maximum harvesting efficiency. Also check/adjust combines several times during the day as environmental and crop conditions change.

Historical Weather Days: *0*; Real Weather Days: *125*

CHAPTER 6
Rice Fertility

Tim Walker

On Delta soils, a high rice yield depends on the right rates and timing of plant foods. Well-timed fertilization should maximize yields and minimize lodging and damage from diseases. Fertilizer needs differ according to native fertility, cropping history, source of fertilizer nutrients, cultivar, and water management.

A soil test tells you about the soil's fertility needs. If you grow rice in rotation with soybeans, collect soil samples in the late fall or early winter after the soybean crop. The flooding common in rice production changes soil chemistry, so the results are less accurate when soils are sampled after the rice crop. Sample early enough that the lab results can be processed and used for the following crop. Fields that have not been planted in rice before may be sampled the same way as any other field. Take a separate sample from any area where an unusual operation has occurred, such as areas that have been cut deeply, filled, cropped differently, or limed. Be sure to label samples taken from unusual areas. In fields where rice has been grown, sample four separate areas of the field:

- the area where water enters the field
- the center area of the field near the flood gates
- the center area of the field away from flood gates
- the area of the field or farthest from well or flood gates

Today's technology can help you decide where to sample. If you use them correctly, yield maps created from real-time data may show you other places to soil sample. If yield tends to be low in the same area of a field over a period of 2 or 3 years, that area probably has a nutrient deficiency. You can collect samples from those low-yielding areas and from higher-yielding areas.

Nitrogen

Correcting a nitrogen (N) deficiency increases plant height, panicle number, leaf size, grain number, and number of filled grains. The number of filled grains is especially important because it largely determines the yield capacity of a rice plant. The number of tillers that develop during the vegetative stage heavily influences the number of panicles. Grain number and number of filled grains are determined mostly in the reproductive stage. Overfertilizing, underfertilizing, or fertilizing at the wrong time can decrease rice yields. It is important to apply the optimum rate of N fertilizers at the appropriate growth stage for the individual rice cultivar.

Nitrogen Sources

As the rice plant develops, you may use either an ammonium or a nitrate form of N. The N source you should use depends on when you apply it. For pre-flood application, urea or ammonium sulfate is better than nitrate fertilizer. Ammonium nitrate (34-0-0) and urea (46-0-0) are equally effective at midseason. Areas where soil pH is high or organic matter is low, such as cut areas, may need ammonium sulfate, but using ammonium sulfate as a total preflood N source is a waste of money. On high pH soils, flood the field within 5 to 7 days after applying N fertilizer to avoid serious N losses because of ammonia volatilization (Table 6.1). Agrotain®, a commercially available product, decreases N losses due to ammonia volatilization and can be applied to the urea prills, but best yields are achieved by flooding in a timely manner.

Ammonium-N is relatively stable in a flooded environment and is more effective than nitrate-N. The nitrate-N may leach or evaporate as a gas under saturated conditions, a process called denitrification. Also, at this early growth stage, the rice plants can best use the ammonium form. Water management that insures a continuous flood provides the most efficient use of N.

The early season N should be applied to a dry soil surface just before flooding. Flood the field as soon as possible after N application to incorporate the N. Maintain the flood at least 3 weeks to maximize N uptake and prevent losses through denitrification and ammonia

Table 6.1. Agrotain treated urea compared to urea alone at three application times prior to flood establishment.

Source	Time (DBF[a])	Yield (bu/A)
Agrotain + Urea	0	166
Urea	0	167
Agrotain + Urea	3	169
Urea	3	163
Agrotain + Urea	10	169
Urea	10	152

[a]Days before permanent flood establishment.

volatilization. Nitrogen applied to wet soil stays on the surface and can be lost because of breakdown by soil organisms, causing denitrification or volatilization. Nitrogen applied into the flood can also be broken down and lost.

Midseason occurs when the rice plant changes from the vegetative to the reproductive growth stage. You can identify this period in the life of a rice plant by the appearance of the "green ring" and the initial elongation of the upper internodes. It's easier to identify this developmental stage using a combination of thermal energy accumulation (DD_{50}) and observation of internodes. By midseason, the physiology of the plant and a larger feeder root system at the soil surface allow faster N uptake and use. Almost all midseason N is taken up by the plants within 3 to 4 days of application. At midseason, ammonium nitrate is as effective as urea is.

To reduce herbicide injury to rice, make the midseason N application at the proper growth stage of the rice but after the herbicide application. If possible, stop the movement of water through the field to stabilize the flood before applying midseason N. Resume pumping 3 days after each midseason N application.

Nitrogen Rates

Nitrogen (N) requirements for rice vary depending on cropping history, soil type, and the rice cultivar. Recently cleared, high organic matter soils or catfish ponds will probably need little or no N the first year. About 100 to 120 pounds of N per acre should be enough the second year. Old cropland should get 150 to 180 of N pounds per acre, depending on the cultivar and soil type. Soils with CEC's higher than 20 tend to need more N than soils with lower CEC's.

Apply one-half to two-thirds of the total amount of N that will be used in the growing season on a dry soil surface just before flooding. Apply the rest at midseason. If fields can be flooded within 5 days and uniform application is not a problem, semi-dwarf cultivars often respond better when 60 to 75 percent of the N is applied preflood.

Sometimes environmental conditions do not allow for optimum fertilizer timing. For example, if rice has reached 6 to 8 inches tall and the field is wet with no dry weather in the forecast, it is sometimes better to apply 100 pounds of urea per acre and flood the field as quickly as possible. As soon the field is flooded with 2 to 4 inches of water, make a second application of urea at the rate of 100 pounds per acre. Make a third application of 100 pounds of urea per acre when the uppermost internode begins to elongate. Apply another 100 pounds of urea per acre 7 days after that. This application method is often called "spoon feeding." If N deficiencies become apparent before midseason, time the midseason N application based on the plant need, not the growth stage.

There are times when you should apply N before planting or to seedling rice. When you will be water-seeding a field and will continually hold the water across the field until maturity, apply the entire preflood N before flooding and planting. You should also apply N before planting or to seedling rice in continuous rice production. When you incorporate a lot of organic material into the seedbed, apply 50 pounds of urea (23 pounds nitrogen) per acre during seedbed preparation or when the seedling rice is 2 to 3 inches tall. When sulfur (S) is required, you can substitute 100 pounds of ammonium sulfate per acre for the 50 pounds of urea. This will supply enough N to feed the microorganisms that decompose organic material and for young rice plants before the flood is established permanently.

If for any reason the permanent flood is delayed until plants are 7 to 10 inches tall, you may need to add N. Watch closely the weed growth habit on fields where you apply N early or before planting. Using early N tends to stimulate weed growth, and you may use a residual herbicide to help control problematic grasses. You may need to flush the field to provide enough moisture to keep the young rice plants actively growing and to reactivate residual herbicides. Immediately before flooding, apply another 90 to 120 pounds of N per acre. Make midseason N application as usual.

When rice plants need N, they become stunted and yellow. This yellowing, or chlorosis, usually appears first on the lower leaves, while the upper leaves stay green. A severe N shortage in rice makes the leaves turn brown and die. The lower leaves usually turn brown, or fire, beginning at the leaf tip and moving along the midrib until the entire leaf is dead.

Table 6.2 gives N recommendations for cultivars popular in Mississippi. Subtract 10 pounds of N from the recommended N rate for every 1 percent increase in organic matter above 3.0 percent.

Nitrogen Notes

What nitrogen does:

- Gives dark green color to plants.
- Causes rapid growth.
- Increases yield of leaf, fruit, or seed.
- Increases protein content of seeds.
- Feeds soil microorganisms when they decompose low-N organic materials.

Table 6.2. Recommended N rates for cultivars grown in Mississippi

	Clay Soils			Silt Loam Soils		
Cultivar	PF	MS	BS	PF	MS	BS
	(lbs N/A)					
Bowman	120-150	30-60	0	120	45	0
CL 131	120-150	30-60	0	120	45	0
CL 161	90-120	30-60	0	90	60	0
CL 171-AR	120-150	30-60	0	120	45	0
Cocodrie	120-150	30-60	0	120	45	0
Cybonnet	120-150	30-60	0	120	45	0
Sabine	120-150	30-60	0	120	45	0
Trenasse	90-120	30-60	0	90	60	0
Wells	90-120	30-60	0	120	45	0
XL 723	120-150	0	45	120	0	45

PF = Preflood
MS = Midseason
BS = Boot Split

Phosphorus

Historically, rice seldom responded to phosphorus (P) in Mississippi, but P deficiencies have been routinely found since the mid-1990's and appear to be increasing. Here are some of the reasons yield is now responding to P fertilizers: less fertile subsoils are exposed after landforming; the pH of much of the older rice acreage is almost or greater than 7.5, which can decrease P availability; and phosphorus is mined from the soil each time grain or cotton is harvested. Rice seldom responds to P application on black, heavy clay soils after landforming. On lighter soils, P-deficient subsoil with a high clay concentration may be exposed with cuts as shallow as 6 inches. Where soil pH is 7.5 or greater, maintain high P levels according to the soil test. The critical level for soil test-P increases as soil pH increases. One way to maintain P at productive levels is to apply P-fertilizer at a rate equal to crop removal. Table 6.3 shows the amount of P that is removed with the harvested grain or lint of commonly grown crops in the Delta.

Table 6.3. Nutrients removed with the harvested portion of the crop.

Crop	Nutrients Removed N	P	K
	---------- (lb/bu) ----------		
Corn	0.75	0.19	0.24
Cotton (lint lb/bale)	32.00	6.10	16.60
Rice	0.55	0.13	0.15
Sorghum (lb/cwt)	1.50	0.33	0.32
Soybean	4.00	0.35	1.20
Wheat	1.15	0.24	0.28

Phosphorus Sources and Timing

Two available P sources are Triple Superphosphate (0-46-0) and Diammonium Phosphate (18-46-0). These sources are equally effective in supplying the plant with P. The proper timing can be as important as the rate of P-fertilizer (Table 6.4).

Table 6.4. Rice yield response to application time averaged across 25, 50, and 100 lbs P_2O^5/acre.

P Timing	Yield (bu/A) Site 1	Site 2	Site 3
1-Leaf	177	105	185
Preflood	128	77	173
Midseason	75	88	--
Boot	45	83	--
Untreated	14	69	176
Soil pH	8.1	7.8	6.0
Soil test P (lb/A)	9	28	11

You must apply P at the proper time to ensure optimum results. Maximum yields have been obtained when P-fertilizer is applied at the time of planting to spiking rice. However, as long as enough P is in the plant before tillering, you can get satisfactory yields. There are two good application options that should fit well into current production practices. The first option is to apply P just before planting and incorporate with either a field cultivator or the drill. The second option is to apply the P at spiking to 3-leaf rice and allow a rain or flush to incorporate the fertilizer into the soil. This method would fit especially well when no S is needed. When a low to medium rate of P is needed (30 to 40 pounds P_2O_5 per acre), 100 pounds per acre of 18-46-0 can supply the P and early season N for improved vegetative growth. However, if a high rate of P is needed (80 pounds P_2O_5 per acre), you can blend DAP (18-46-0) and TSP (0-46-0) to avoid overapplying N during the seedling stage.

Phosphorus deficiencies are noticeable about 5 to 7 days after permanent flood establishment. Common signs of P deficiency are spots in the field where the rice has slender stalks, does not tiller, and is less colorful than the dark, shiny green of well-fertilized rice. Phosphorus deficiency can also delay maturity and cause low yields. Add phosphorus only when a soil test shows a deficiency or where deep cuts were made on land-formed areas.

Flying on 100 pounds per acre of TSP or DAP can affect yield but will not give maximum yields.

Because P deficiencies seldom occur over an entire field, using variable rate technology may be cheaper than making blanket applications. This technology allows you to apply the right amount of fertilizer in the right places, which can increase yields and decrease the amount of fertilizer used.

A good soil sampling program will help identify fields or areas within fields that have a P deficiency. Table 6.5 shows the current P recommendations from the Mississippi State University Soil Testing Laboratory.

Table 6.5. MSU-ES phosphorus recommendations based on soil test-P levels

Range	lbs P/A	Recommended lbs P_2O_5/A
Very Low	0-18	80
Low	18-36	40
Medium	36-72	30
High	72-144	0
Very High	>144	0

Phosphorous Notes

What does phosphorus do?

- Helps seedlings germinate.
- Stimulates early root formation and growth.
- Gives rapid and vigorous start to plants and promotes good root growth.
- Is associated with greater straw strength.
- Stimulates blooming and aids in seed formation.
- Hastens maturity.
- Gives winter hardiness to fall-seeded grains.

Potassium

Potassium (K) levels in Delta soils are usually medium to high, and rice response to potassium in Mississippi has not been documented. If you grow rice in rotation with soybeans, remember that soybeans remove a lot of K from the soil. You must consider nutrient removal for all crops grown in the rotation, especially on lighter soils. If soybean and rice yields continue to increase and no maintenance fertilizer applications are made, rice is more likely to respond to potassium.

Rice is also more likely to respond to K after landforming light soils. Sometimes sandy horizons are exposed after topsoil is removed. In these situations, a yield response to K is more likely.

Potassium Notes

What does potassium do?

- Increases vigor and disease resistance in plants.
- Produces strong, stiff stalks, which reduce lodging.
- Plumps the grain and seed.
- Helps form and transfer starches, sugars, and oils.

Potassium deficiency symptoms are listed below.

- Leaves mottle, spot, streak, or curl, starting on the lower leaves.
- Lower leaves scorch or burn on margins and tips. Sometimes these dead areas fall out, leaving ragged edges.
- In rice, the tip of the leaf dries up or fires, starting at and proceeding down from the edge, usually leaving the midrib green.
- Rice lodges before it matures because of poor root development and straw strength.

Add potassium only when a soil test shows a deficiency.

Sulfur

Most of the soil sulfur (S) is contained in the soil organic matter. Often an S deficiency occurs after landforming. A soil needs at least 20 pounds per acre of plant-available S. You must ask for an analysis for available S when sending a soil sample to the MSU-ES soil testing lab, as analysis for available soil S is done only by request. You can correct an S deficiency with an application of gypsum the preceding fall or with ammonium sulfate during the growing season or after the symptoms occur on rice. Apply about 24 pounds of S per acre (100 pounds per acre of ammonium sulfate) to recently land formed areas. In some cases, this rate may need to be doubled to supply enough S throughout the growing season. You may make maintenance applications of S in following years by applying a nitrogen/sulfur blend of 41 percent N and 4 percent S. Base the rate on N recommendations for the cultivar grown. If there is an S deficiency, you'll see symptoms in young rice about 10 to 14 days after permanent flood establishment or during the late reproductive stages after prolonged flooding.

Sulfur Notes

What does sulfur do?

- Increases root growth
- Helps maintain dark green color
- Stimulates seed production
- Encourages plant growth

An S deficiency causes uniformly chlorotic (yellow), stunted rice plants. These symptoms look like those of N deficiency. However, unlike N, S does not move from older to younger plant parts. Sulfur deficiency on the younger growth may be the same shade of light green or yellow as is the older growth. Younger growth may also be lighter green with even lighter veins.

Micronutrients

Most of the soils suited to rice in the Mississippi Delta are high in micronutrients. Most soils range from pH 5 to 6.5. Few soils have native pH values higher than 7.5. Micronutrient deficiencies should be suspected only on light-textured, sandy loam, and silt loam soils. When the pH is higher than 7.5 on lighter-textured soils, a zinc deficiency may occur. Zinc deficiencies are especially common when soil has low organic matter, high phosphorus, and low zinc content. Symptoms of zinc deficiency in young seedling rice include the following:

- plants that appear bronzed and may have a very small, irregular, rusty pattern on the leaves
- leaves that are pale and drooping
- leaves that turn pale green on the bottom half 2 to 4 days after flooding
- leaves that become yellowish and start dying 3 to 7 days after flooding

The worst symptoms of deficiency appear in cold-water areas and where the flood is deepest. If you find a zinc deficiency before planting rice, add the recommended rate of zinc sulfate as determined by a soil test or add 35 pounds of zinc sulfate per acre before planting. If you see a zinc deficiency after rice has emerged, apply zinc chelate at the rate of 0.5 to 1 pound metallic zinc per acre as a foliar spray. Zinc chelate can be tank mixed with propanil for application if a propanil application for weed control is needed. If the symptoms occur after a permanent flood is established, drain the field. Apply zinc chelate at 1 pound per acre or 2 to 2.5 pounds per acre of the zinc complexes. Reflood the field after zinc application.