AGRICULTURAL
MU Guide
PUBLISHED BY UNIVERSITY EXTENSION, UNIVERSITY OF MISSOURI-COLUMBIA

Guidelines for Producing Rice Using Furrow Irrigation

Paul W. Tracy, Barry D. Sims, Steven G. Hefner and John P. Cairns
Department of Agronomy and University Extension

Traditional rice culture in Missouri uses flood water management. Reasons for flooding include efficient growth, rice's poor water stress tolerance and its ability to flourish in submerged soil where many competitive grasses and broadleaf weeds cannot survive.

Flooded management of any crop requires intensive equipment, labor and energy inputs, and is costly and time consuming. It also requires large water supplies. Water tables in many rice growing regions are diminishing. Restricted water use, priority use (human, industrial or transportation), or lack of adequate water supplies may lead to regulation. Possible consequences include prohibitive production costs or even banning of rice production in some regions.

Environmental concerns over water use are constantly debated. If rice can be produced using less water, then it will be less affected by these concerns.

Many areas of the world grow non-flooded rice, often referred to as upland rice. These regions (Asia, Africa and South America) receive large amounts of rainfall during the rice growing season. Upland rice varieties tend to be of lower quality, short or medium grain and may not be well suited for United States rice consumption or market outlets.

Much rice production research has centered on good quality, long or medium grain rice varieties produced with intermittent basin flooding or sprinkler irrigation systems. Intermittent flooding reduces water consumption. However, levee building and maintenance and harvest problems associated with levees, as well as difficulties with rotation from basin to non-basin crops, require increased labor, high energy inputs and high costs. Sprinkler irrigation systems also have high initial equipment costs and energy requirements.

Recent experiments conducted by Missouri rice producers and MU personnel indicate that the advantages of furrow irrigation over intermittent-flooded or sprinkle-irrigated rice include less labor, energy requirements and initial cost; and easier rotation to crops such as corn, soybeans or cotton. Advantages of furrow-irrigated rice compared to flooded rice include reduced levee construction, use of ground equipment in place of airplanes for agrichemical applications, quick field drying for timely harvest, less land preparation when rotating to other crops, and potential use on soils which will not maintain a permanent flood.

Disadvantages of furrow rice culture vs. intermittent flooding or sprinkle irrigation are not apparent. Drawbacks of furrow-irrigated vs. flooded rice systems are yield reductions of 5 to 20 percent, maturity delays, costlier weed control, potential water stress and lack of pertinent information about the system. **It should be noted that on fields well suited for flooded rice management, furrow-irrigated rice will rarely, if ever, outproduce flooded rice!**

The purpose of this publication is to introduce producers to the furrow-irrigated rice system and help interested individuals decide whether that system has potential for use on their farms.

Site selection and land preparation

Furrow-irrigated rice can be produced on many southeast Missouri soils. Loamy sand soils are questionable and sandy soils should be avoided or tried on a limited acreage basis for evaluation. Sandy soils with a compacted plow layer may support furrow-irrigated rice. Sandy loam, loam, silt loam, silty clay loam and clay soils all have potential for growing rice by furrow irrigation. Planting and initial stand emergence will be easier on loamy soils than clay soils.

Field grade is the most important factor in choosing and preparing a field for furrow-irrigated rice. Precision-graded land is best, but may not be needed on short-run fields. Most land furrow irrigated for corn or soybeans in the past is adequate. Water must run down every furrow: skipped furrows or poorly graded land creates potential for water stress and yield loss.

Field preparation starts with discing. One discing prior to bed preparation usually is adequate behind a low-residue crop such as soybeans. Following corn or rice, more discings may be required.

After discing, raised beds should be built using a bed conditioner "hipper." Most hipping equipment in southeast Missouri is designed for 30- or 38-inch spacings between raised beds. Either spacing can be used for furrow-irrigated rice. Spacings greater than 38 inches have not been studied, but probably will not provide adequate conditions unless soils allow good lateral wicking action of irrigation water.

Bed spacing and height may differ by soil texture, and should be made to allow complete soil saturation across the entire soil surface (including ridge-tops) after each irrigation. Bed height must be tall enough to prohibit irrigation water from breaking over bed tops.

A tail levee should be constructed after planting or stand establishment. Levees prevent water loss and maintain near-flooded conditions at the field's lower end. Side levees 50 to 400 feet in length can be built if the field has considerable side slope, and will prevent water from becoming too deep at low corners. A "typical" furrow-irrigated field is illustrated in Figure 1.

Planting practices

Two planting practices have been studied. Prepared beds can be physically lowered, after which rice grain is drilled using a standard grain drill

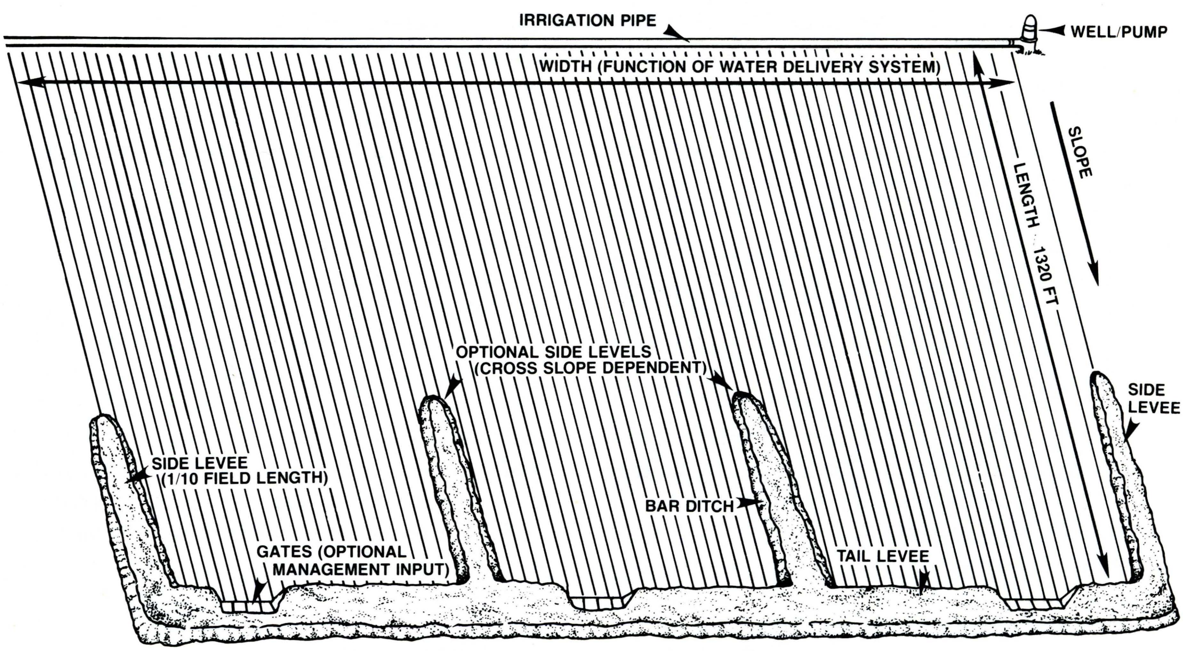

Figure 1. Schematic example of a standard furrow-irrigated rice field.

adjusted for micro-relief; or rice can be broadcast, after which grain is incorporated into the soil by physically lowering the beds or by "re-hipping."

It is recommended that rice seed be drilled instead of broadcast. The greatest benefit of drilling is accurate seed placement. Grain drills respond with better placement on 38-inch bed spacings compared to 30-inch bed spacing because of more gradual micro-relief. Many rice varieties have poor epicotyl strength (pushing power) and have difficulty emerging through soil. Seven-inch drill spacings and 1/2-inch seed depth placement has been successful. Other drill spacings may also work but have not been studied.

The broadcast system leads to seed placement ranging from the soil surface to the depth of tillage and frequently leads to poor stand establishment. Broadcast seeding should only be done on loam or sandy loam soils that have little tendency to crust, and with rice varieties that possess excellent stand establishment capabilities. Drilling is recommended on all soils, especially on clay or clay loams.

Seeding rate should be approximately equal or slightly higher in furrow-irrigated compared to flooded rice fields, and will be variety-dependent. Studies in Missouri in 1988 and 1989 have shown 100 to 150 pounds (1.75 to 2.5 million seed) Lemont rice per acre to be optimum for furrow-irrigated rice (Table 1).

Rice should be irrigated (flushed) immediately following planting unless rainfall is imminent. Flushing is necessary to enhance seed germination, seedling emergence and early season crop growth. Soft soil also provides an easier medium for uniform stand establishment in the event of non-uniform seed placement. Flushing of furrow-irrigated rice fields is quicker and more efficient than flushing flooded rice fields.

Variety selection

Long grain rices often grown under flooded conditions in Missouri can also be grown by furrow irrigation. Seedling emergence and vigor are key considerations in selecting varieties. Since the permanent flood is not used to aid in weed control, quick stand establishment and canopy closure is essential. The best adapted varieties possess excellent emergence, seedling vigor, canopy closure and weed competitiveness. However, Lemont, a variety known for poor stand establishment, has been grown successfully (150 bushel/acre) in Missouri using furrow irrigation management.

Grain yields of selected varieties grown by furrow irrigation in 1988 are listed in Table 2. Overall yields in this variety test were poor due to broadcast non-uniform seed placement, but differences among varieties were obtained. Lemont yielded less than varieties that displayed quicker stand establishment or earlier maturing varieties such as Newbonnet. Excellent seed quality (percent germination, fungicide treatment, etc.) is necessary with any variety.

Table 1. Seeding rates for furrow-irrigated rice.[1]

Seeding Rate[2] (lbs. rice/A)	Rice Yield 1988	Rice Yield 1989
	bu/A	bu/A
50 (approx. 850,000 seed/ac.)	107	95
100	130	108
150	121	110
200	119	107

[1]These studies were conducted on a Portageville, Mo. clay soil.

[2]Rice variety = Lemont

Table 2. Comparison of selected rice varieties grown under furrow-irrigated water management.

Variety	Yield (bu/acre)
RAX 2011	119
Newbonnet	99
Mars	95
Lemont	92

For further information on rice variety evaluations in Missouri, see the Missouri Crop Performance publication for rice, produced annually through the Missouri Agricultural Experiment Station. Although short and medium grain rice varieties are not traditionally grown in Missouri, they may be well adapted for the furrow-irrigated system. Future tests of these cultivars under furrow irrigation will be done if interest warrants.

Water management

Rice can be grown without flooding so long as moisture stress is avoided. The key to water management in furrow-irrigated rice is to maintain moist soils through frequent irrigation or rainfall. Irrigation scheduling is dependent on air temperature, evapotranspiration rate, rainfall events, soil texture and soil permeability. Most furrow-irrigated rice fields require 1 to 2 inches of water every three to four days during peak evapotranspiration periods (July and August) and four to eight days in May, June and September.

Irrigation events should be scheduled when soils on the upper and center sections of the field show visual signs of drying in the upper 2 inches, or when soil moisture deficit compared to field capacity has reached approximately 1 inch. At this point, the tail levees will still maintain a partial flood in the lower section of the field. Total water use has been found to be approximately half for furrow-irrigated compared to flooded rice (Table 3). Gated aluminum or polypipe can be used in water delivery.

Weed control

Weed control and management in furrow-irrigated rice may require at least one additonal herbicide application than conventional flooded rice production.

Cultural, mechanical (preplant tillage) and chemical weed control methods all should be integrated.

Cultural control. Cultural weed control consists of rotating rice with crops in which problem weeds may be more easily controlled and providing conditions that promote good stand establishment and early season crop vigor. Early season vigor provides a more competitive rice crop with weed interference and better tolerance to herbicide treatments. A sparse early season rice stand may allow more weeds to emerge and compete with the crop. A good quality, weed-free seed source is also very important to prevent the introduction of new weeds.

Mechanical control. Tillage, although not useful while rice is growing, is very important prior to planting. All weeds should be controlled before planting to prevent early season weed-crop competition.

Chemical control. Herbicides are vital to a good weed control program for furrow-irrigated rice. Growers should scout regularly for new weed flushes after previous herbicide treatments, since without permanent flooding, weeds will germinate and emerge throughout the growing season. Early season herbicide programs should be planned similarly to those for flooded rice.

A **pre-emergence** residual herbicide may be more important in furrow-irrigated rice, since less water is used than in flooded rice culture. A couple of weeks free of weeds will aid in good stand establishment and early season crop vigor.

Prowl has provided excellent residual grass control in furrow-irrigated rice studies. Prowl can be applied preemergence to the rice or tank-mixed with the early season propanil (Stam) treatment. It should be used especially when sprangletop is a problem, since propanil is weak on sprangletop.

Bolero is effective only if the soil surface is maintained wet, which can be very difficult. Although a furrow-irrigated rice field can be flushed frequently with water, it is difficult to maintain a uniformly moist soil surface because the tops of the bed will dry out much faster than the bottoms of the furrows. Therefore, Bolero has not provided adequate residual annual grass control in MU furrow rice studies.

Three herbicides are currently registered for **postemergence** annual grass control in rice: propanil (Stam, and others), Arrosolo, and Whip. Arrosolo also will provide contact and some residual grass control.

Propanil should be applied postemergence to small, one- to two-leaf annual grasses. Propanil should be applied according to the grass growth stage and not the rice growth stage. Growers often wait until the entire rice field has emerged before propanil is applied. When these practices are followed, annual grasses are at different growth stages and frequently are too large for effective and consistent control with propanil.

Early season propanil applications often cause some foliar injury (leaf burn) to small rice plants. However, rice recovers rapidly and outgrows this early season injury within one to two weeks after treatment. The potential risk of slight leaf burn is much less than the loss in weed control that could occur if weeds are too large for effective control. Propanil treatments may have to be repeated according to label directions if additional grass flushes occur. Propanil can also be tank-mixed with Prowl to add residual grass control.

A package mix containing the active ingredients propanil and molinate (Ordram), Arrosolo provides control of susceptible annual grasses and will also provide residual grass and selected broadleaf weed control. It is weak on sprangletop. Arrosolo can be applied to rice in the spiking to three-leaf stage and to barnyardgrass in the one- to two-leaf stage. Fields should be sealed by flushing after application. Residual control can be reduced when applied to wet soil.

Whip provides excellent grass control (sprangletop, barnyardgrass, crabgrass, foxtails, fall panicum, and johnsongrass). It should be applied to four-leaf to tillering rice, but before panicle initiation.

Whip has performed well in a weed control program following the first propanil treatment. It should

Table 3. Irrigation water applied to furrow-irrigated rice on a clay soil in southeast Missouri, 1988-1990.

Field Year	Irrigation Water	Rainfall
Furrow-irrigated field 1988	14 inches	19 inches
Furrow-irrigated field A 1989	13 inches	15 inches
Furrow-irrigated field B 1989	21 inches	15 inches
Flooded field B 1989[1]	44 inches	15 inches
Flooded recommendation[2]	30-40 inches	

[1]Field B was split 1/2 flooded and 1/2 furrow irrigated.
[2]Arkansas Extension recommended rice water use on clay soils.

Table 4. Effect of N rate and application timing on furrow-irrigated rice.

Application Ratio	N Rate (lbs/a)			
	1988		1989	
	180	240	180	240
	bu/a			
1:1:0[1]	129	85	123	141
4:1:1[2]	128	112	121	116
3:1:1:1	90	84	125	109
1:1:1	84	108	107	127

[1]Ratios refer to preflood:1/2 inch internode elongation: 14 days post internode elongation:28 days post internode elongation.
[2]Recommended ratio for flooded Lemont rice.

Table 5. Effects of N source, application timing, and Dicyandiamide on furrow-irrigated rice.

Application Timing (lbs./a)	N Source							
	1988				1989			
	Urea	AS	SCU	UAN	Urea	AS	SCU	UAN
	bu/a							
180+0+0[1]	103	101	134	97	112	126	123	133
180+0+0 DCD	111	127	121	102	119	126	–	117
120+30+30	116	121	95	102	126	129	109	130
60+60+60	102	102	94	95	112	109	69	117

[1]ratios refer to preflood:1/2 inch internode elongation:1/2 inch internode elongation + 14 day N fertilizer application timings.

not be applied with a crop oil or surfactant. Do not apply Whip within 14 days following fertilizer applications. Avoid standing water for 5 to 7 days after application. Nitrogen should be applied after treatments. Do not tank-mix Whip with other pesticides. It should not be applied within 65 days of harvest.

Broadleaf weeds must be controlled during early seedling stages to prevent weed competition and yield reductions. Heavy infestations of broadleaf weeds common to conventional row crops have infested furrow-irrigated rice. Fields should be scouted regularly, problem weeds identified and the correct herbicides matched to the weeds to be controlled.

Several programs have been tested for early season broadleaf weed control in furrow-irrigated rice. Excellent control has been achieved with timely broadleaf herbicide treatments in a program using propanil. Basagran, Blazer, propanil, Arrosolo and 2,4-D amine control certain broadleaf weeds in rice. 2,4-D controls a broad spectrum of broadleaf weeds and has been very effective in furrow-irrigated rice research. Refer to label for specific weeds for each herbicide.

Excellent weed control has been obtained in MU research with the rice herbicides currently available. However, one to two additional herbicide treatments may be necessary. Late emerging annual grass weeds have been common in university rice trials. Furrow-irrigated rice fields should be scouted frequently to monitor weed control during the growing season. More intensive management is necessary for successful weed control compared to flooded rice culture.

The herbicide recommendations in this publication were current at the time of writing. However, this guide is not meant as a substitution for reading the herbicide label. For specific information on the use of each herbicide labelled for weed control in rice, see Weed Control Guide for Missouri Field Crops (Publication MP575).

Fertilization

Submergence generates a number of soil electrochemical and chemical changes that may be beneficial for rice production. The layer of water above the soil functions as a barrier and interrupts normal gas exchange between the soil and the atmosphere. The dramatic decrease in soil oxygen interrupts the nitrification process and aids in maintaining the fertilizer nitrogen (N) in the ammonium (NH_4) form, where it is less susceptible to denitrification losses.

Accelerated N loss was anticipated when rice was grown under fluctuating moisture regimes. Yet field experiments indicate that the optimum rate for the high N requirement rice variety Lemont is similar under furrow irrigation to that of flooded Lemont rice (Table 4). Therefore, N recommendations for furrow Lemont rice should closely parallel those for flooded rice. Best yields were attained when application timings contributed a large amount of N for early growth, followed by a later application of N at internode elongation.

Data in Table 4 were generated on clay textured soils. Furrow rice crops produced on sandier soils may require modified N management. Recent research on furrow-irrigated rice in Arkansas has shown that on low N requirement rice varieties (Tebonnent), furrow irrigation may require slightly more N (especially early season) than do flooded irrigation systems.

In flooded rice, NH_4-based N sources such as urea and ammonium sulfate (AS) have been more efficient while nitrate (NO_3) sources such as urea-ammonium nitrate (UAN) and ammonium nitrate are more susceptible to N loss by denitrification. Volatilization loss of N from NH_4-based fertilizers can occur if they are improperly applied, especially with N sources such as urea which possess a high degree of alkalinity.

Different N fertilizer source options may be available with intermittent-irrigated rice (Table 5). Applications of UAN become more feasible in the absence of floodwater because the nitrate component of the fertilizer is less susceptible to denitrification losses. Each midseason application of UAN should not exceed 30 pounds N to avoid excessive vegetative burn.

Slow-release fertilizers, such as sulfur-coated urea (SCU), produced good furrow rice yields when entire N quantities were applied early in the season. SCU also has the advantage of reducing the number of N applications and minimizing N loss due to volatilization. However, SCU is currently cost prohibitive for rice production. Broadcast applications of urea should be made when the soil surface is dry and then accompanied by an irrigation or rainfall event within 24 hours to move the fertilizer into the soil and minimize volatilization.

Table 6. Furrow-irrigated rice milling quality data.

Location/Year	Brown Rice	Milled Rice	Head Rice	Hulls
		(%)		
Pemiscot Co./1988	83	76	65	17
Stoddard Co./1988	82	73	66	18
Pemiscot Co. #1/1989	80	69	64	20
Stoddard Co./1989	80	68	64	20
Pemiscot Co. #2/1989	80	68	62	20
Pemiscot Co. #2/1989 (flooded rice)	80	72	66	20

The advantage of using a nitrification inhibitor, if effective, is that only one N application is required. Results from using dicyandiamide (DCD) as a nitrification inhibitor on furrow-irrigated rice indicated limited promise at best (Table 5).

Phosphorus fertilization for furrow rice may differ from that of flooded rice. Submergence during flooding also induces soil pH adjustments to near neutrality and mineral changes that enhance phosphorus availability. As a result, phosphorus fertilization of rotational crops supplies adequate phosphorus to flooded rice crops.

In the absence of flooding, furrow-irrigated rice may respond to phosphorus fertilization on low phosphorus soils. Lime and sulfur requirements often supplied in appreciable amounts through irrigation water may be required in the absence of flooded conditions.

Disease control

Rice disease pressure may be different in furrow-irrigated rice. Furrow-irrigated rice has a slightly lower canopy humidity. Therefore, fungal diseases that thrive in warm-humid conditions may respond differently.

The two major rice diseases in Missouri are blast and sheath blight. Blast usually begins on stressed plants (sometimes initially identified on levee-planted rice). Blast problems may be greater in furrow-irrigated rice due to increased moisture stress potential. Sheath blight problems are greatest when this soil-borne fungus attacks rice stems at the highest possible point. It floats on water and attacks rice at the water depth level. It can be assumed that sheath blight infestations are reduced in furrowed rice fields, which have no floodwater.

Good policy for all rice producers (regardless of irrigation delivery system) is to plant disease-tolerant varieties, scout fields, and apply fungicides when disease pressure reaches threshold levels.

Milling quality

Many producers are concerned that non-flooded conditions will adversely affect rice milling quality. A summary of milling quality data collected on furrow-irrigated rice fields in Missouri during 1988 and 1989 is shown in Table 6. Milling quality across all locations was excellent, with no head rice values below 60 percent. The only location where rice milling quality was directly compared between flooded and furrow-irrigated conditions showed that the flooded rice had slightly better head rice yields. But in this field the furrow-irrigated head rice was above dockage levels.

Conclusions

Rice can be produced in southeast Missouri using furrow irrigation as the water delivery system. However, furrow irrigation is not intended to replace flood water management, but to serve as an alternative in environmental situations that prohibit flooded soil conditions. Principal situations where furrow irrigation may be appropriate include: expanding rice acreages into non-traditional rice soils for rotation; weed control (especially red rice); and disease control, or protection of federal base acreages, on soils incapable of maintaining a permanent flood and in areas where water is limited, or irrigation pumping costs are excessive.

As with any new management system, rice growers intending to furrow irrigate should do so on **small acreages for 1 to 3 years** until they are confident that it fits into their farming operation.

Acknowledgements

The authors would like to express special thanks to **Gary Mayberry**, a rice producer in Stoddard County, Missouri who developed the furrow-irrigated rice production concept and many of the production practices discussed in this publication.

Agencies that contributed funds and resources for research discussed in this publication include: **Missouri Rice Research and Merchandising Council, Missouri Fertilizer and Aglime Advisory Council, Tennessee Valley Authority** and **Potash and Phosphate Institute.**

University Extension
UNIVERSITY OF MISSOURI COLUMBIA

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914 in cooperation with the United States Department of Agriculture. Gail L. Imig, Director, Cooperative Extension Service, University of Missouri and Lincoln University, Columbia, Missouri 65211. ■ An equal opportunity institution.