Arkansas FURROW-IRRIGATED RICE HANDBOOK

U of A
DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

ARKANSAS RICE CHECK-OFF

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Table of Contents

Chapter 1

Introduction

Furrow-irrigated rice (FIR), also known as row rice or upland rice, has increased in acreage in recent years. Since 2015, the practice of FIR has increased from less than 1% of total acres to over 10% as of 2019 (**Table 1-1**). The primary reasons for FIR adoption are to simplify crop rotations and decrease time and expenses associated with flood-irrigated rice. However, additional benefits could include water savings, which will prove more beneficial as water resources are further depleted. Since rice is a semiaquatic plant, upland (non-flooded) production research efforts are limited. Contained in this handbook are general recommendations to follow if attempting FIR. Beginning in 2020, FIR is eligible for crop insurance through USDA-RMA (see page 40 for more information).

Table 1-1. Annual Arkansas furrow-irrigated rice acres and percent of total acres

Year	FIR Acres	Percent of Total Acres
2012	4,156	0.3%
2013	3,706	0.4%
2014	5,519	0.4%
2015	11,456	0.9%
2016	40,797	2.7%
2017	39,018	3.5%
2018	109,472	7.7%
2019	118,000	10.5%

Photo 1-1. Early-season furrow-irrigated rice

FIR has been grown in excess of 30 years in small pockets of the state, but little work has been published on its success or lack thereof. Most research in the Mid-Southern United States has shown a significant decrease of anywhere from 10% to 40% rice grain yield compared to a flood-irrigated system. However, there are several differences between the FIR grown today and that in previously published research. Most research trials did not involve true furrow irrigation, but mimicked the practice using flush irrigation. Work involving a true furrow-irrigated system has been scarce and was completed prior to the widespread adoption of hybrid cultivars.

Anecdotal reports have shown success with the furrow-irrigated system over the last several growing seasons, particularly with hybrid cultivars. Yields within 10% of past flood-irrigated production have been common, with slight yield increases in FIR observable in certain situations.

Chapter 2
Cultivar Selection

In FIR, general stress tolerance and disease reactions are critical in selecting appropriate cultivars. **Table 2-1** provides suggestions for selecting cultivars based on a combination of noted tolerance to stress, disease resistance, and field observations.

Blast is of serious concern in FIR due to the lack of a permanent flood. Therefore, selecting a cultivar that is less susceptible to blast is a critical management decision for successful FIR production. Choose a hybrid or select a less susceptible variety that makes it easier to manage blast with a fungicide. **Please note that in some situations, a disease such as blast may not be effectively managed with fungicides.** See Chapter 6 for more information on disease ratings and management in FIR.

Standard cultivar performance trials do not provide dependable predictions of performance for row rice production. Modern breeding programs focus on cultivars intended to perform optimally in flooded conditions – these cultivars may not necessarily perform similarly in the absence of a flood. One consideration is that hybrid cultivars are able to develop a more extensive root system, which could aid in increased drought tolerance and ability to scavenge nutrients (particularly nitrogen and phosphorus) at the upper end of a FIR production field.

The general expectation is that similar yields to flooded rice production can be achieved, but growers should be prepared for a 10% yield reduction in row rice production depending on field conditions and management capabilities. The goal of this system is to achieve increased profit margins by reducing input costs in other areas that offset the potential yield loss.

Table 2-1. Rice cultivar recommendations for furrow-irrigated rice systems

Cultivar	Suggested Use
RT 7301	Recommended
RT 7321 FP	Recommended
RT 7521 FP	Recommended
RT CLXL745	Recommended
RT Gemini 214 CL	Recommended
RT XP753	Recommended
ARoma 17	Use with caution
CL111	Use with caution
CLL15	Use with caution
CL153	Use with caution
Jupiter	Use with caution
PVL02	Use with caution
Titan	Use with caution
Diamond	Generally avoid
LaKast	Generally avoid
PVL01	Generally avoid
CL151	Not recommended
Francis	Not recommended
Roy J	Not recommended

*Cultivars listed in alphabetical order within each recommendation category

Management Key:
Generally, cultivars with superior blast resistance packages are recommended for FIR production.

Chapter 3

Stand Establishment

Seeding Rates

Research concerning seeding rate recommendations in FIR has been limited to date. Working primarily from research conducted in flat-planted studies for flood-irrigated rice, certain recommendations appear appropriate for FIR production.

In flood-irrigated rice, it is recommended that seeding rates be increased 10% for no-till seedbeds and early seeding and 20% for poor seedbed condition or clay soils. In FIR, if planting no-till onto flat ground prior to pulling water furrows or planting onto the previous year's soybean beds, increase standard seeding rate by 10%. If using freshly pulled beds or planting on clay soils, increase standard seeding rate by 20%.

It should be noted that in many instances growers have been successful with standard (unadjusted) seeding rates in FIR. However, planting with a drill on uneven bed surfaces or on clay soils that crack can lead to reduced seedling stand density. Planting onto freshly pulled beds can further decrease seedling stand density and uniformity by uneven seed placement if drills cannot be set adequately. Seeds on top of fresh beds could very well end up 2-3 inches deep, while seeds in the furrows may remain on the soil surface. The lack of a flood further increases weed pressure where rice plant stands are low.

Seed Treatments

Insecticide and fungicide seed treatments should be used in FIR. Rice water weevil is only a concern on the bottom portion of the field where standing water is likely to occur. Grape colaspis can still be incredibly damaging in FIR situations. Insecticide seed treatments are the best control option for grape colaspis at this time. A seed treatment containing a neonicotinoid insecticide, such as CruiserMaxx® Rice, NipsIt INSIDE®, or NipsIt® Rice Suite, is recommended to protect against grape colaspis in FIR.

Rice billbug is a pest of increasing concern in FIR compared to flood-irrigated fields. This pest was previously only a problem on levees as it prefers to attack rice near the base of the stem, but this leaves the vast majority of a FIR field vulnerable to rice billbug. Yield loss of more than 10% has been reported with severe infestations. Research is ongoing to develop best practices for managing rice billbug. Data is limited, but the addition of a diamide insecticide (Dermacor X-100 or Fortenza) may protect yield potential when rice billbug is present.

Management Key:
Correct insecticide seed treatment choice is vital to yield protection in FIR.

Seedling diseases can be an issue in FIR. Although drainage is improved with the use of furrows, much of the field will have standing water after a rain or irrigation event. In conditions with a combination of standing water and cool temperatures, seedling diseases can negatively impact rice growth and lead to seedling stand loss. Fungicide seed treatments provide short-term protection and allow for plants to “outrun” seedling diseases. Use a combination of fungicide seed treatments that provide control of Pythium, Rhizoctonia, and other microbes that may cause seed rots.

Planting Practices

A range of planting options exist for FIR systems. Rice may be planted flat with water furrows pulled after planting or the furrows pulled prior to planting. This method works particularly well on heavier clay soils. Raised beds may be constructed ahead of planting to allow for stale planting, constructed immediately prior to planting, or beds from the previous season may be used if harvest conditions permit. Each of these practices has been used with success. Adjust seeding rates as appropriate and utilize insecticide and fungicide seed treatments.

The slope of the field will have a measurable impact on the decision of how to plant FIR. Fields that fall in a single direction (straight-levee fields) can be planted flat and water furrows pulled to convey water down the field. However, this practice should not be used on fields that have cross-slope as water will not remain in the furrows for the length of the field.

In fields with cross-slope it is preferred to use beds from the previous year or newly constructed beds so that water is restricted to the furrow. It is essential that the integrity of the furrows is not compromised for the entirety of the season, especially on heavier textured soils.

If a field has a steep slope (greater than 0.2'/100'), it is preferred to drill rice in the direction of the furrows. This will place rice consistently in the bottom of the furrow and help slow the progression of water down the field and allow for beds to soak through. Even on shallow-sloped loamy soils this may be the best approach to allow greater wicking across the beds that tend to seal over due to increased silt content.

If a field has a shallow slope (less than 0.2'/100'), it may be preferred to drill rice at a slight angle across the field. This will allow water to flow more evenly down the field and be less restricted by the rice in the furrows.

Adjust the drill press wheels to provide adequate but not excessive down pressure for their locations relative to the furrow and the bed so that the drill "fits" the furrows and beds. That is, provide more down pressure for furrows and reduce it for beds. Oftentimes the planting depth will be deeper on the beds than the furrows, but if the rice is covered with soil, it should be acceptable. Avoid planting too deep into the beds (greater than 1.5 inches).

Photo 3-1. Furrow-irrigated rice with a field grade of 0.05'/100' planted on an angle across beds

Photo 3-2. Furrow-irrigated rice being drilled into freshly constructed beds

Chapter 4

Fertility Management

Nitrogen (N)

Nitrogen management in FIR systems has been evaluated extensively over the past several growing seasons. Currently, multiple options appear favorable depending on soil texture and field management considerations. Where possible, it is recommended that furrows be end blocked to keep tailwater on the field after an irrigation event. Collected tailwater up to a certain depth does not have a detrimental effect as with other row crops, and the standing water can assist with management of the system. Water management will also affect N management. See Chapter 8 for more information on end blocking and irrigation management in FIR.

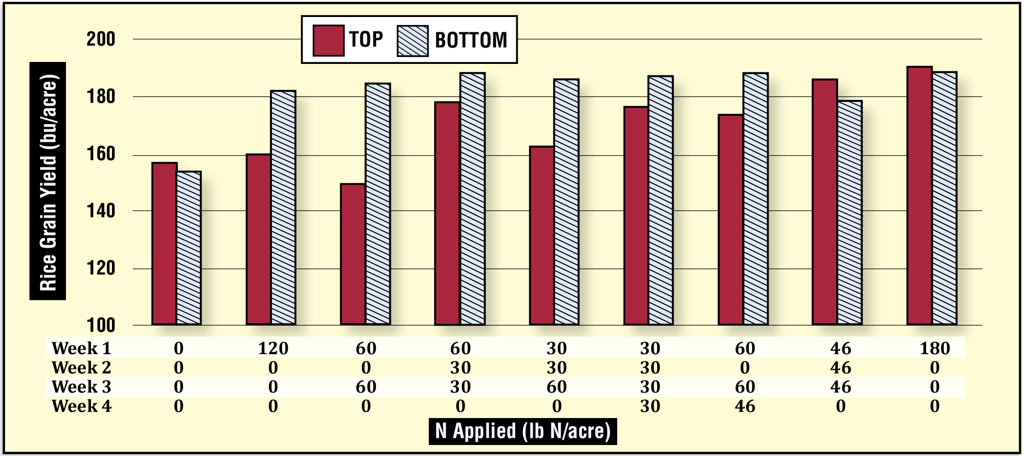
In fields with shallow slopes, holding as much water in the field as possible will increase N efficiency. For these shallow sloped fields, the single pre-irrigation application method can be utilized on the portion of the field where a flood will be held throughout the remainder of the season. However, make sure to only apply a single preflood application up to where a flood can be safely backed up to during the first irrigation after N application. The single preflood application should not be used in areas of the field that cannot be safely flooded until the rice increases in size due to the fact that N loss will be very likely if a permanent flood cannot be established timely. Additionally, due to the fluctuating moisture of the FIR system, it is recommended to use the urease inhibitor n-butyl thiophosphoric triamide (NBPT) on all urea applications.

Silt Loam Soils

Managing N in FIR on silt loam soils can be a challenge. Slope of the field, native soil N, and previous cropping history will all play a role in how N should be managed. Following soybean, research has indicated that a three-way split can optimize yield across both extremes of a FIR field (i.e. the upper, drier portion of the field as well as the lower, flooded portion of the field). Applying three applications of 46 lb N/acre (100 lb urea/acre), spaced 7-10 days apart, has produced optimal yield in the majority of field trials (**Figure 4-1**). Applying one-half of the recommended single preflood N rate at pre-irrigation followed by two additional N applications of one quarter of the recommended N rate each spaced 7-10 days apart is another option that has produced favorable results. It may be noted that an excessive single pre-irrigation rate of 180 lb N/acre (391 lb urea/acre) also produced optimal yield, but this is a risk that does not always pay off. Recommended N rates for specific cultivar and soil type combinations can be found in university publications updated annually. Keep in mind that the total N rate for this alternative approach assumes rice grown in rotation with soybean, an optimum stand density, and that the land has been in cultivation for at least five years. If one of these assumptions is violated, then the total season N rate should be adjusted accordingly. The season total N rate can also be determined using N-STaR and a 0-18-inch sampling depth.

Management Key:
Furrow-irrigated rice on loamy soils can be managed with multiple N strategies, including single preflood (pre-irrigation at 5-leaf stage), a two-way split (50% of preflood N followed by 50% 10-14 days later), or a three-way split (three applications of 100 lb urea/acre spaced 7-10 days apart).

Figure 4-1. Furrow-irrigated rice grain yields on a silt loam soil in Arkansas County, AR with different N splits. Solid bars represent the top (upper one-third of the field) while hatched bars represent the bottom (lower one-third of the field). N source was urea + NBPT. Application timings were Week 1 = 5-leaf stage and Weeks 2, 3, 4 were made in 7-day increments following Week 1.

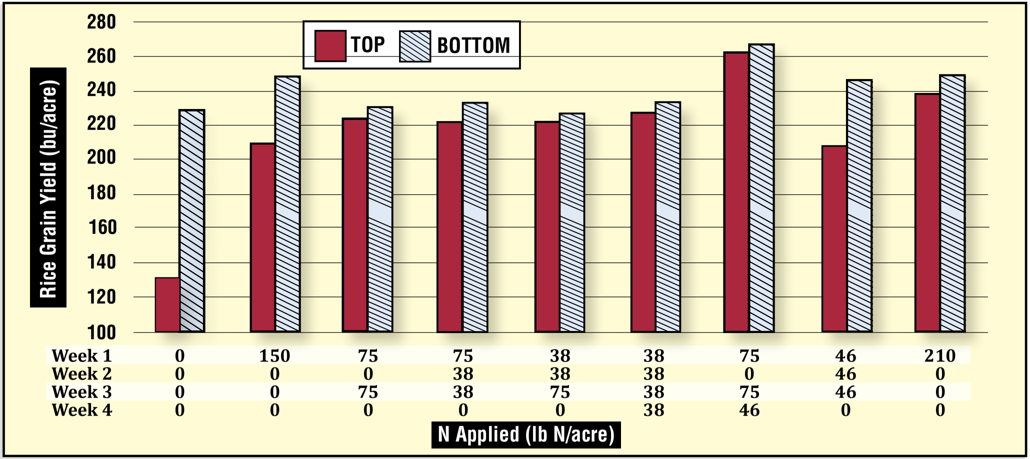


Clay Soils

Furrow-irrigated rice appears to perform very well on clay soils. Based upon trials conducted in 2018 and 2019 in a production setting, splitting the total in-season N rate into three applications appears to produce optimal yield consistently (Figure 4-2). Applying 75 lb N/acre (163 lb urea/acre, one-half of recommended single pre-flood N rate) at pre-irrigation followed by 75 lb N/acre (163 lb urea/acre) 10-14 days later followed by a third application of 46 lb N/acre (100 lb urea/acre) 7-10 days after the second application has consistently out-yielded all other application methods on clay soils in U of A System Division of Agriculture trials. The base preflood application rate for a clay soil is 30 lb N/acre (65 lb urea/acre) more than the silt loam requirement. Again, keep in mind that this rate is based upon rice following soybean and may need to be increased if any of the assumptions mentioned previously are violated. The N-STaR method to determine total in-season N requirement is also valid on clay soils using a 12-inch sample depth.

Management Key:
Furrow-irrigated rice grown on clay soils, where no flood is held, requires an additional 100 lb urea/acre than flood-irrigated rice to achieve maximum yield potential.

Figure 4-2. Furrow-irrigated rice grain yield on a clay soil in Mississippi County, AR with different N splits. Solid bars represent the top (upper one-third of the field) while hatched bars represent the bottom (lower one-third of the field). The N source was urea + NBPT. Application timings were Week 1 = 5-leaf stage and Weeks 2, 3, 4 were made in 7-day increments following Week 1.



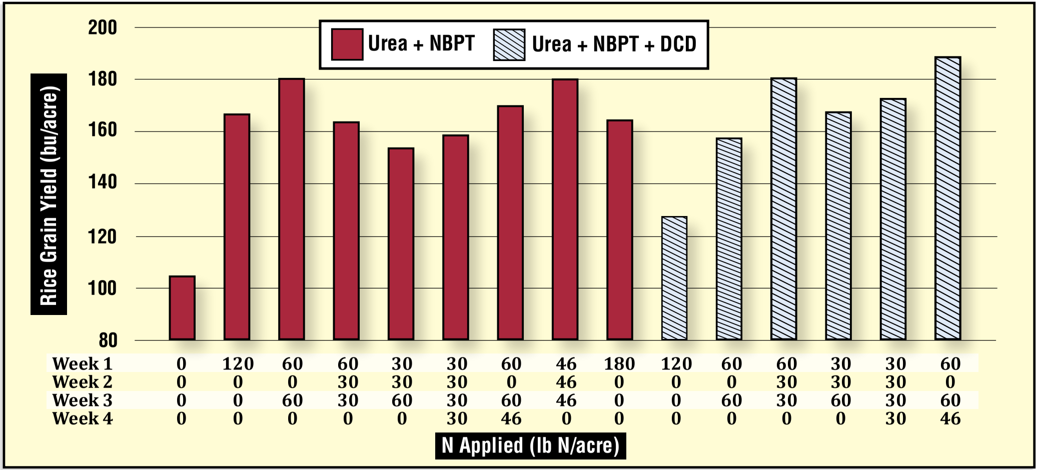
Additional N Management Recommendations

The Trimble® GreenSeeker® handheld is recommended to determine midseason N needs in flood-irrigated rice. However, use of GreenSeeker is not generally recommended in FIR at this time. This is due to the fact that N recommendations for FIR include split applications up to near midseason timing and that the majority of FIR acres are planted with hybrid cultivars which do not generally receive a midseason N application. The lack of a flood in combination with slower vegetative growth creates possible reflectance issues that likely shift the response index when compared to flood-irrigated rice. Preliminary research indicates that if GreenSeeker is used in FIR, a response index (RI) value of 1.1 should be used to determine additional N needs (compared to a RI of 1.15 for flooded rice).

The late boot N recommendation of 30 lb N/acre (65 lb urea/acre) applied between full boot and beginning heading still applies to hybrid cultivars grown under the FIR system and would be applied in addition to the above N recommendations. Work is currently ongoing to validate the late boot N application in FIR, but there is nothing to suggest that this recommendation should differ between irrigation management systems.

Alternative urea-based products were tested alongside urea + NBPT at multiple silt loam sites, including urea + NBPT + dicyandiamide (DCD, a nitrification inhibitor). Urea + NBPT consistently (9 times out of 10) performed equal to products containing the nitrification inhibitor, as exhibited in **Figure 4-3**. At this time, it appears that the chance of increased yield with added DCD is very low and is not worth the extra cost for adding DCD. Research in this area is ongoing.

Figure 4-3. Furrow-irrigated rice grain yield on a silt loam soil in Arkansas County, AR with different N splits and products. Solid bars represent urea + NBPT while hatched bars represent a product containing urea + NBPT + DCD. Application timings were Week 1 = 5-leaf stage and Weeks 2, 3, 4 were made in 7-day increments following Week 1.



Other Nutrients

Phosphorous (P) has the potential to be significantly less available in a FIR system. The presence of plant-available P is significantly increased when a permanent, continuous flood is applied. Therefore, when using furrow or overhead irrigation methods, P deficiency might be more prevalent in areas with high soil pH (>7.0). Soils that have a combination of low soil test P and high pH should be monitored closely for P deficiency symptoms, especially following N applications when rice experiences periods of rapid growth. It is ideal to apply P fertilizer in the spring just before planting or up to pre-irrigation for FIR, as this leaves less time for the P to be precipitated in less available forms.

Management Key:
Phosphorus should be applied as close to planting as possible in FIR, especially on soils with high pH (>7.0) and falling in the low or very low soil test P range (<16 ppm soil test P).

Other nutrients, including potassium (K) and most micronutrients, tend to behave similarly to rice grown under a continuous flood. One particular nutrient to watch for in FIR would be zinc (Zn). The majority of Zn deficiencies in rice become obvious within a few days after establishing a permanent flood, but the lack of a permanent flood in most FIR systems may mask the symptoms of Zn deficiency. Although Zn deficiencies are not necessarily more or less common in FIR, the deficiency symptoms will generally be much more subtle than when a permanent flood is applied and thus may need to be scouted more carefully.

Chapter 5

Weed Management

The lack of a flood changes weed management for rice considerably. Palmer amaranth and other upland broadleaves can become season-long issues in FIR. Additionally, grass species such as large crabgrass, broadleaf signalgrass, and goosegrass can cause frustration and lead to additional applications.

Producers should be prepared to budget for four herbicide applications to manage these difficult-to-control weeds. Said another way – producers should budget for an additional herbicide application in FIR compared to their herbicide program for flooded rice. Multiple residual herbicides will be needed throughout the growing season to compensate for the lack of weed suppression accomplished by the establishment of a permanent flood. However, repetitive irrigation can increase herbicide activation and ground-rig applications are possible.

A good conventional herbicide program in FIR conditions may include Command® + Sharpen® applied at planting; followed by Propanil + Bolero® or Prowl® + Bolero early postemergence; followed by Ricestar® HT + Facet® or a similar program that provides residual grass control multiple times throughout the season. Permit®, Permit Plus®, or Gambit® should be included as needed for yellow nutsedge control. Other sedges, such as rice flatsedge and smallflower umbrella sedge, may require an application of Basagran + Propanil or Loyant to effectively control them because ALS resistance in these sedges is common. The reduced need for aquatic weed control in FIR is often replaced by the need for multiple applications of grass and broadleaf herbicides. Gambit, for example, will provide POST and residual control of hemp sesbania and jointvetch. Care should be taken to follow labeled cut-off dates and timings for certain herbicides and pre-harvest intervals (see MP44, MP519, or product label).

For Clearfield® or FullPage® cultivars in FIR fields, Command + Sharpen followed by Clearpath® (or Preface® + Facet); followed by Newpath® or Preface; followed by Beyond® or Postscript® may be a sufficient program for grass control, contingent upon weedy rice and barnyardgrass being susceptible to these herbicides. Many producers find the length of residual offered by Newpath or Preface in Clearfield or FullPage rice to be a good fit in FIR scenarios; however, care should be taken not to rely solely on the ALS-inhibitor chemistry to prevent resistance.

Broadleaf weeds that the flood normally suppresses will require more attention in the FIR system – particularly Palmer amaranth. There are limited control options for Palmer amaranth in rice, just like most other crops. Sharpen® can provide preemergence control, but control can be significantly reduced in areas where PPO-inhibitor resistance is an issue. Loyant® at 8-10 fl oz/acre provides excellent control of Palmer amaranth that is less than 6 inches tall but will have little to no residual activity. If Palmer amaranth is greater than 6 inches in height, the full 16 fl oz/acre rate of Loyant should be used; however, be aware crop injury has been observed in some situations, especially with hybrid rice. Grandstand® + Propanil has the potential to provide good control of smaller Palmer amaranth (less than 4 inches tall) up to ½-inch internode elongation, but also has no residual control. 2,4-D may also be an option in areas where its use is legal and must be applied between maximum tillering and ½-inch internode elongation. Check the Arkansas State Plant Board website for specific restrictions regarding the use of 2,4-D in rice.

For weed control ratings, please see the MP44 Recommended Chemicals for Weed and Brush Control or the 2020 Rice Management Guide.

**Mention of a specific product does not constitute endorsement and is provided only as examples.*

Management Key:
To achieve good weed control in FIR systems, scout more frequently for proper herbicide selection and focus on timeliness of application.

Photo 5-1. Early-season furrow-irrigated rice with broadleaf weeds emerging

Chapter 6
Disease Management

Aerobic conditions created by the upland nature of a FIR system are more favorable for development of rice blast. There is a known risk to planting fields to cultivars rated very susceptible, susceptible, or moderately susceptible for blast. The safest option is to select a relatively resistant cultivar to complement fungicides. Under favorable conditions, fungicides may not be able to suppress enough of the neck blast in FIR in susceptible cultivars.

All commonly grown varieties have some level of blast susceptibility and should be scouted regularly to manage this disease – even more so than flooded fields. FIR fields can often be better managed with relatively resistant cultivars. To date, most hybrids and a few varieties have performed well in a FIR system. It is important to note that a new race of the blast pathogen may evolve and have the possibility of infecting resistant rice cultivars.

In a FIR system, be prepared to treat with a fungicide when required. Fungicide application decisions depend on the resistance level of your cultivars, weather conditions, field history, and field management. In a season where blast is prevalent, FIR should be managed very carefully because of its increased susceptibility to blast. If fungicide application is required, two well-timed fungicide applications should be made: the first as heads begin to emerge from the boot (boot split to 10% heading) and the second approximately 7-10 days later when ~70% of the head is out of the boot.

Sheath blight and other minor diseases of flooded rice sshould be of little concern in FIR. However, monitoring sheath blight occurrence is important since the fungus can infect plants in moist, non-flooded environments such as when the disease occurs as aerial blight in soybean. Scouting both the top and bottom of the field is recommended as sheath blight can develop in both environments. Cultivars susceptible to kernel smut and false smut will still require preventative treatments particularly if the season is cool and wet, N fertilization is excessive, and the field has a history. Moreover, remember these two diseases are aggravated with late planting, especially false smut.

Photo 6-1. Moderate sheath blight infection in the top end of a furrow-irrigated rice field

Management Key:
If planting blast-susceptible cultivars in FIR, multiple fungicide applications are needed for management of blast, but still may not be sufficient in certain situations.

See **Table 6-1** for a list of disease ratings for selected cultivars. Listed cultivars can be grown under FIR conditions. Extreme care should be taken if growing a cultivar susceptible to blast. Cultivars rated as very susceptible for blast are not included in the table and should not be considered for FIR production.

Table 6-1. Disease ratings for selected cultivars for furrow-irrigated rice production

CULTIVAR	BLAST	SHEATH BLIGHT	KERNEL SMUT	FALSE SMUT	BACTERIAL PANICLE BLIGHT
RT 7301	MR	MS	--	--	MR
RT 7321 FP	--*	MS	S	MS	--
RT 7521 FP	--*	S	MS	VS	--
RT CLXL745	R	S	S	S	MR
RT Gemini 214 CL	MR	S	MS	VS	--
RT XP753	R	MS	MS	S	MR
ARoma 17	MS	MS	S	S	MS
CL111	MS	VS	S	S	VS
CLL15	MS	S	S	S	S
CL153	MS	S	S	S	MS
Jupiter	S	S	MS	MS	MR
PVL02	MS	MS	--	--	S
Titan	MS	S	MS	MS	MS
Diamond	S	S	S	VS	MS
LaKast	S	MS	S	S	MS
PVL01	S	S	VS	VS	S

*Limited data suggests these cultivars are also MR or R for blast resistance.
Reaction: R = Resistant; MR = Moderately Resistant; MS = Moderately Susceptible; S = Susceptible; VS = Very Susceptible (cells with no values indicate no definitive Arkansas disease rating information is available at this time). Reactions were determined based on historical and recent observations from test plots and in grower fields across Arkansas and other rice states in southern USA. In general, these ratings represent expected cultivar reactions to disease under conditions that most favor severe disease development.

Chapter 7

Insect Management

As mentioned earlier, insecticide seed treatments are strongly recommended in FIR. A large complex of soil pests, such as grape colaspis, wireworms, and rootworms will feed on rice in a FIR system. These pests can cause severe stand loss leading to a reduction in yield. Neonicotinoid seed treatments (CruiserMaxx Rice or NipsIt INSIDE) will protect plants from infestations of these soil pests.

Rice billbugs tunnel into rice plants near the base and can result in blank heads – severe infestations have been observed causing 10% yield loss across the field. Diamide insecticide seed treatments (Dermacor or Fortenza) should help reduce issues with billbug.

Combinations of a neonicotinoid seed treatment (CruiserMaxx Rice or NipsIt INSIDE) with a diamide seed treatment (Dermacor or Fortenza) will aid in control of the soil pest complex and billbug control.

The armyworm complex (true armyworms and fall armyworms) may be more severe in FIR with no flood present as a barrier to prevent armyworms from migrating into the field. If diamide seed treatments are being used for control of rice billbug, then rice should be protected from armyworm feeding as well.

Rice stink bug (RSB) management remains similar to that for flooded rice with a threshold of 5 RSB per 10 sweeps the first 2 weeks of heading and 10 RSB per 10 sweeps the next 2 weeks. If uneven heading is severe between the top and bottom of the field in FIR, the field may have to be treated as two separate fields, with sampling and insecticide treatments being made independently.

Chapter 8

Irrigation Management

Shallow beds should be used for FIR. Beds should be just adequate to convey water down the furrows without breaking over or cutting across beds from furrow to furrow. In clays or heavy textured soils, the beds can be extremely shallow because the preferential flow of water follows the cracking nature of the soil, which dominates the movement of water in a FIR field. Thus, on a clay soil the bed height is very forgiving. However, on silt loam soils, a bed that is too shallow will break over easily creating water stress in un-irrigated rows. Also, if bed height is too aggressive, the rice plants on the top of the bed will often not receive adequate water if the soil seals and does not wick across the bed easily. This will limit N and water availability and also prevent herbicide activation, so bed height is critical to success in FIR.

Photo 8-1. Early season furrow rice irrigation

Set implements as shallow as is comfortable to ensure a successful furrow for the season. If rotating with soybeans, consider using the existing furrows. Re-dressing existing beds can tend to leave a rough bed and is not advised. If old beds need to be reformed, considering knocking them down and reforming. Beds can be established in the fall if desired to allow for earlier planting and less field work in the spring.

Depending on soil type, a wider bed may be preferable if water soaks across beds easily. Bed widths of 36-40 inches are acceptable; however, on silt loams that seal, it is suggested to use 30-inch beds to provide more soil area for irrigation water to contact. Bed height and width choice are driven by equipment availability, soil type, and land slope. Use the combination that works best for the conditions. Larger beds on some soil types can have difficulty wicking moisture across the entire bed. In some situations, salt concentrations can accumulate in the top center of beds as water evaporates and cause injury to rice – especially early in the season.

Next, fields should have adequate irrigation capacity with a reliable irrigation pumping plant to irrigate the field in 24-30 hours. Both gated pipe and lay-flat polypipe have been used successfully in FIR. The irrigation pipeline and sets should be planned with computerized hole selection (CHS) such as Pipe Planner (www.pipeplanner.com) to ensure that water is uniformly applied across the crown of the field.

Management Key:
Avoid FIR production in fields that have a history of salt issues or injury.

Photo 8-2. Delayed maturity and shortened canopy height due to moisture stress in the middle of 60" beds

Additionally, it is suggested to use surge irrigation in FIR, especially if soil sealing is experienced during the season on silt loams or on clays if set times are long or it is difficult to get the water to advance through the field. Surge irrigation improves the down-furrow uniformity, thus improving water delivery to the rice plants at the tail end of the field. If end blocking does not impound water over a significant part of the field, then surge irrigation should be used. For fields where end blocking results in a large area of impounded floodwater, a surge valve may provide less benefit. However, in either situation a surge valve should help to keep the upper area of the field saturated longer as the irrigation water cycles from one side of the field to the other.

Manage irrigation so that only a small amount of tail-water is created, or if end blocked terminate the advance before the water reaches the flooded rice so that the recession (remainder of the water) replenishes the flood at the end blocked furrows. Large volumes of tailwater leaving a FIR field indicate a problem with water management or infiltration. Seek the corrective remedies mentioned above.

Initial research on FIR has indicated that furrow irrigation, when properly managed, can use 10% to 40% less water than conventional flood-irrigated rice. However, if soil sealing is excessive or sets are not well managed, FIR can quickly become excessively irrigated and result in very low water use efficiency.

Water use for FIR has the potential to be less than for flood-irrigated rice depending on rainfall, soil type, and environmental conditions. It should be noted that in some studies comparing furrow and flood irrigation, it was difficult to achieve similar yields with furrow irrigation to those achieved with flood irrigation. However, variations in agronomic management of these fields may have played a greater role than simply irrigation management – as similar yields to flood irrigation are achieved in many cases.

Photo 8-3. End blocking or a "tail levee" holding water on the low end of a furrow-irrigated rice field. Maintain 1-2 inches of freeboard to capture rainfall

General recommendations for improving irrigation efficiency in FIR include the use of end blocking the field. This can be done by blocking the drains and in some cases constructing a 'tail levee' at the bottom of the field to back water up in the field resulting in the lower end of the field holding some level of flood throughout the season. However, care should be taken to not hold too deep of a flood in the lower end of the field, especially early in the season. Too deep of a flood can result in decreased tillering and stretching of the rice, which can lead to lodging issues closer to harvest. Generally, anything deeper than 6-8 inches can begin to cause issues. Holding too deep of a flood can and will ultimately lead to yield loss in the lower end of the field.

Irrigation Timing

Rice is different than other row crops because the rooting depth is shallow and it is more drought sensitive than other row crops. Application rates in furrow irrigation are typically between 2-3 ac-in/ac, but in FIR the target application rate should be near 1.0-1.5 ac-in/ac if the field is irrigated frequently (every 2-3 days). Measure flow from wells or pumps to ensure adequate irrigation volumes are being applied. A surge valve can assist in getting the correct irrigation volume applied to a field or set.

Recent data suggest that hybrid cultivars can be pushed even further in terms of water availability and irrigation frequency. With appropriate irrigation capacity, it is possible to irrigate FIR fields on both clay and non-sealing silt loam soils once every 5-7 days and still produce optimal yield. However, maintaining adequate soil moisture may require irrigating every 2-3 days on sealing silt loam soils or where irrigation application rates are low.

Soil Moisture Sensors

Soil moisture sensors are a useful tool in deciding when to irrigate FIR. Watermark™ sensors or other soil moisture sensors can be used to track the soil water balance, monitor rice water demand, and ensure irrigations are effective in FIR. Sensors should generally be placed at shallower depths in FIR than other row crops. For example, if using Watermark sensors place shallow sensors at 4-6 inches and 8 inches. Place at least one sensor at 12 inches and/or 18 inches to monitor any subsoil moisture change. Generally, sensor readings for depths past 12 inches will not change during the season, so make decisions based on the shallow sensor readings. Sensors should be placed in the top center of the bed soon after rice emerges, so sensor installation does not damage rice roots. Damaged plants may not represent the water use of undamaged plants in the field.

Irrigation on silt loams and clays should be made when a 45 kPa threshold is exceeded. Zero (0) kPa is saturated, so keeping sensor reading in single digits is not recommended, but do not allow sensor readings to greatly exceed 45 kPa before irrigating. **Table 8-1** shows the average grain and milling yield when utilizing soil moisture sensors to trigger irrigation. All thresholds resulted in similar yield at both sites and were not affected by soil texture (clay vs. silt loam). This suggests a threshold greater than 45 kPa may be possible. Additionally, no statistical difference was reported between all three FIR irrigation regimes and the flood-irrigated control. However, there were notable yield differences between the top, middle, and bottom of the field for FIR (**Table 8-2**).

Table 8-1. Furrow-irrigated rice grain and milling yield with irrigation threshold based on soil moisture sensors at a 4-inch depth averaged across Keiser and Pine Tree sites in 2018 and 2019

Irrigation Threshold	Grain Yield	Head Rice	Total Rice
	bu/acre	---------%---------	
15 kPa	200.9	49.2	71.0
30 kPa	202.5	50.2	70.8
45 kPa	202.3	48.8	70.9
Flood	212.2	52.2	70.3

Table 8-2. Furrow-irrigated rice grain and milling yield as dictated by area of the field averaged across irrigation trials at Keiser and Pine Tree sites in 2018 and 2019

Area of Field	Grain Yield	Head Rice	Total Rice
	bu/acre	---------%---------	
Top	190.3	47.9	70.7
Middle	201.1	49.5	70.8
Bottom	215.0	50.8	71.3

A very conservative program is keeping levels near field capacity or in a range of 20 to 30 kPa for most soils. However, experience with soil moisture monitoring has shown that even a 2-3 day schedule may not be adequate to maintain 20 to 30 kPa for periods of the season on sealing soils when rice plants are at peak transpiration and water demand.

Sensors can be helpful in deciding if irrigation can be delayed if rain is expected or if a moderate rainfall event has occurred and you are unsure of whether it was enough to skip an irrigation. With all types of sensors, monitor the trend of the sensor readings. The upper sensors should respond to irrigation and plant water use. A good result is a repeatable pattern within a range of the sensor readings that correlate to visual observations about crop condition.

Irrigation practices for FIR will vary depending upon soil type, field slope, irrigation capacity, and the cultivar being grown. As a general rule, hybrids will be more tolerant to water/drought stress than will pureline varieties. Use the tools mentioned and adapt the furrow irrigation system that is successful for the conditions.

Management Key:
In FIR, use shallow beds, computerized hole selection, irrigate every 3-5 days and monitor irrigation with soil moisture sensors. Figure out what works for your soil type.

Irrigation Termination

Little information is available for determining the timing of irrigation termination for FIR systems. Care should be taken not to terminate irrigation too early and risk drought stressing plants as they fill remaining kernels. As a general rule, most FIR will require one more irrigation past the DD50 recommended drain time, or 25 days after 50% heading for long-grain cultivars and 35 days after heading for medium-grain cultivars. If a flood is held at the bottom of the field, it may be pulled at the general DD50 drain date for flood-irrigated rice. Irrigation will be necessary longer in FIR than in flooded rice, as flooded fields have saturated soil that will take more time to dry out. It may be appropriate to drain at the standard timing and still follow up with a final irrigation event.

Chapter 9

Budgets

Budgeted costs differ among rice production systems (conventional variety, Clearfield variety, conventional hybrid, and Clearfield / FullPage hybrid) for flood and FIR. Expenses and revenue can vary greatly for individual fields and farming operations. Initial field setup and management are the driving factors, and the greatest differences can be seen between fields using the previous year's beds to eliminate tillage passes versus creating new beds specifically for FIR.

Table 9-1 is included to generally compare differences in field activities between flood-irrigated and FIR systems.

Notable differences in costs associated with flood ver-sus FIR are in regard to tillage and field passes, N fertil-ization, herbicide program, fungicide program, applica-tion costs, and potential water savings (**Tables 9-2 and 9-3**). For certain inputs, higher costs are associated with FIR due to the inclusion of additional N to offset losses, additional herbicides to improve residual weed control, additional fungicide applications primarily for control of blast disease, and additional application costs. These additional inputs may not always be needed but should be included in conservative budgets. It has also been attempted in the FIR budget to capture some lower variable expenses associated with lower fuel, repair, and maintenance costs, though these items will vary greatly for different farming operations.

Table 9-1. Comparison of field activities for flood-irrigated versus furrow-irrigated conventional hybrid rice in Arkansas

FIELD ACTIVITY	INPUT	FLOOD	FIR
Disk	Tillage	✓	✓
Cultivator	Tillage	✓	✓
Land Plane	Tillage	✓	--
Hipper	Tillage	--	✓
Ditcher	Tillage	✓	--
Ground App	Herbicide 1	--	✓
Aerial App	Herbicide 1	✓	--
Ground App	Mixed Fertilizer	✓	✓
Grain Drill	Seeding	✓	✓
Make Levees	Levees	✓	--
Seed Levees	Seed Levees	✓	--
Levee Gates	Levees	✓	--
Aerial App	Herbicide 2	✓	--
Ground App	Herbicide 2	--	✓
Aerial App	Herbicide 3	✓	✓
Aerial App	Pre-irrigation Fertilizer	✓	✓
Aerial App	Herbicide 4	--	✓
Aerial App	Post-irrigation Fertilizer 1	--	✓
Aerial App	Post-irrigation Fertilizer 2	--	✓
Aerial App	Boot Fertilizer	✓	✓
Aerial App	Fungicide	✓	✓
Aerial App	Insecticide	✓	✓
Drain Field	Drain	✓	--
Harvest	Harvest	✓	✓
Remove Levees	Levees	✓	--
Roll Stubble	Tillage	✓	--

Table 9-2. Flood-irrigated example budget for conventional hybrid rice in Arkansas[†]

CROP VALUE	Unit Bu.	Yield 190	Price/bu 5.00	Revenue 950.00
Operating Expense	**Unit**	**Amount**	**Price**	**Costs**
Seed, field	Acre	1.0	136.39	136.39
Seed, levees	Acre	1.0	25.20	25.20
Nitrogen	Lbs	151.80	0.380	57.68
Phosphate	Lbs	87.00	0.193	16.79
Potash	Lbs	100.00	0.173	17.30
Agrotain	Acre	1	10.27	10.27
Herbicide	Acre	1	111.92	111.92
Insecticide	Acre	1	1.75	1.75
Fungicide	Acre	1	6.00	6.00
Ground Apps	Acre	0	7.50	0.00
Air Apps	Acre	3	8.00	24.00
Air App. Lbs	Lbs	330	0.08	26.40
Diesel, Pre-Post Harvest	Gal	4.363	1.90	8.29
Repair & Maint.	Acre	1	6.70	6.70
Diesel, Harvest	Gal	3.082	1.90	5.86
Repair & Maint.	Acre	1	11.40	11.40
Irrigation Energy	Ac-In	30	2.24	67.20
Irrigation System Repair & Maint.	Ac-In	30	0.24	7.20
Supplies (pipe)	Acre	0	0.00	0.00
Survey/Mark Levees	Acre	1	4.50	4.50
Levee Gates	Acre	1	0.70	0.70
Labor, Field	Hours	0.909	11.33	10.30
Drain Field	Acre	1	3.00	3.00
Scouting Fee	Acre	1	8.00	8.00
Crop Insurance	Acre	1	10.00	10.00
Interest	%	5.50	576.85	15.86
Drying	Bu.	190.00	0.40	76.00
Hauling	Bu.	190.00	0.19	36.10
Check Off	Bu.	190.00	0.0135	2.57
Total Operating Expenses				**$707.38**
Returns to Op Exp				**$ 242.62**
Machine & Equip	Acre	1	77.01	77.01
Irrigation Equip	Acre	1	41.52	41.52
Farm Overhead	Acre	1	3.85	3.85
Total Capital Rec & Fixed Costs				**$122.38**
Total Expenses				**$829.76**
Net Returns				**$120.24**

[†]Based on 2020 Row Crop Enterprise Budgets for Arkansas.

Table 9-3. Furrow-irrigated example budget for conventional hybrid rice in Arkansas†

CROP VALUE	Unit Bu.	Yield 190	Price/bu 5.00	Revenue 950.00
Operating Expense	**Unit**	**Amount**	**Price**	**Costs**
Seed, field	Acre	1.0	136.39	136.39
Seed, levees	Acre	0	0.00	0.00
Nitrogen	Lbs	197.80	0.380	75.16
Phosphate	Lbs	87.00	0.193	16.79
Potash	Lbs	100.00	0.173	17.30
Agrotain	Acre	1	10.27	10.27
Herbicide	Acre	1	136.92	136.92
Insecticide	Acre	1	1.75	1.75
Fungicide	Acre	1	6.00	6.00
Ground Apps	Acre	2	7.50	15.00
Air Apps	Acre	2	8.00	16.00
Air App. Lbs	Lbs	430	0.08	34.40
Diesel, Pre-Post Harvest	Gal	2.658	1.90	5.05
Repair & Maint.	Acre	1	5.41	4.68
Diesel, Harvest	Gal	3.082	1.90	5.86
Repair & Maint.	Acre	1	11.40	11.40
Irrigation Energy	Ac-In	25	2.24	56.00
Irrigation System Repair & Maint.	Ac-In	25	0.24	6.00
Supplies (pipe)	Acre	1	3.88	3.88
Survey/Mark Levees	Acre	0	0.00	0.00
Levee Gates	Acre	0	0.00	0.00
Labor, Field	Hours	0.670	11.33	7.59
Drain Field	Acre	0	0.00	0.00
Scouting Fee	Acre	1	8.00	8.00
Crop Insurance	Acre	1	10.00	10.00
Interest	%	5.50	585.17	16.09
Drying	Bu.	190.00	0.40	76.00
Hauling	Bu.	190.00	0.19	36.10
Check Off	Bu.	190.00	0.0135	2.57
Total Operating Expenses				**$ 715.93**
Returns to Op Exp				**$ 234.07**
Machine & Equip	Acre	1	65.26	65.26
Irrigation Equip	Acre	1	41.52	41.52
Farm Overhead	Acre	1	3.26	3.26
Total Capital Rec & Fixed Costs				**$ 110.04**
Total Expenses				**$ 825.97**
Net Returns				**$ 124.03**

†Modified from 2020 Row Crop Enterprise Budgets for Arkansas.

Chapter 10

Crop Insurance Requirements

Furrow-irrigated rice is an insurable production practice beginning in 2020 when following these practices:

1. Select a cultivar rated as:
    a. Moderately resistant (MR) or resistant (R) to blast disease based on respective state university disease reaction ratings; or
    b. Moderately susceptible (MS) to blast disease, if managed with appropriate fungicides and practices to specifically minimize that susceptibility.
2. Plant utilizing drill seeding or broadcast seeding into an unflooded seedbed. Broadcast seeding into a controlled flood is not allowed.
3. Provide irrigation capacity and equipment capable of applying water down each furrow to ensure adequate water delivery to all rice plants in the field.
4. Utilize adequate row spacing and row depth to convey water evenly throughout the field, allowing for complete saturation of the entire field.
5. Apply irrigation every three (3) but no more than five (5) days in the absence of adequate rainfall events until the crop reaches maturity, unless otherwise recommended by a local agricultural expert.
6. Document irrigation and rainfall events; documentation must be made available upon request.
7. Comply with all good farming practices for rice as well as recommendations of local agricultural experts for timing of irrigation events, fertilization, and weed control for furrow irrigation.

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