Water and Energy Conservation Practices for Mississippi Rice Production

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# Acknowledgements

## Collaborators
- Justin Dulaney (Coahoma Co.)
- Earl Kline (Bolivar Co.)
- Collier Tillman (Leflore Co.)
- Buddy Allen (Tunica Co.)
- Kirk Satterfield (Bolivar Co.)

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- Tim Walker (MS DREC)
- Shane Powers (YMD)
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- Jim Thomas (MSU ABE ret.)
- Filip To (MSU ABE)
- MAFES
- MS Rice Promotion Board
- MS Water Resources Research Institute
- YMD

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**Collaborators Support**
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- MS Rice Promotion Board
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From 1982 to 2008, the volume of **irrigation water** required to produce a cwt. rice has declined by ~40%.

U.S. rice producers have worked hard to conserve water and energy.
From 1982 to 2008, the total energy (BTU’s) required to produce a cwt. rice has declined by ~53%.
1980s: Began Conversion to Straight-Levee System

Aerial photo credit: YMD data package
1990’s: Began use of Multiple-Inlet Irrigation in Straight-Levee Systems

Aerial photo credit: YMD data package
## Mid-1990’s: Zero-Grade Rice (no levees)

<table>
<thead>
<tr>
<th>Irrigation System</th>
<th>6-yr Avg. MS Water Use (A-in/A)</th>
<th>Water Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contour-Levee</td>
<td>44 ± 5</td>
<td>0</td>
</tr>
<tr>
<td>Straight-Levee</td>
<td>38 ± 2</td>
<td>14</td>
</tr>
<tr>
<td>Straight-Levee using Multiple Inlets</td>
<td>31 ± 5</td>
<td>30</td>
</tr>
<tr>
<td>Zero-Grade</td>
<td>20 ± 6</td>
<td>54</td>
</tr>
</tbody>
</table>
## Estimated Energy Used By Groundwater-Based Irrigation Systems per A-in Water Delivered

<table>
<thead>
<tr>
<th>State</th>
<th>Diesel (gallons)</th>
<th>Electric (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR (Tacker)</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>MO (Vories)</td>
<td>0.8</td>
<td>30</td>
</tr>
<tr>
<td>MS (Thomas)</td>
<td>0.7</td>
<td>27</td>
</tr>
<tr>
<td>Avg.</td>
<td>0.9 gal</td>
<td>34 kWh</td>
</tr>
</tbody>
</table>

*For every inch of water not pumped, save at least 0.7 gallon diesel fuel per irrigated A.*
## Estimated Energy Savings per Conservation Practice

<table>
<thead>
<tr>
<th>Irrigation System</th>
<th>6-yr Avg. MS Water Use (A-in/A)</th>
<th>Gallons Diesel Saved per Acre</th>
<th>Savings @ $3.00/gal ($/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contour-Levee</td>
<td>44 ± 5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Straight-Levee</td>
<td>38 ± 2</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Straight-Levee using Multiple Inlets</td>
<td>31 ± 5</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>Zero-Grade</td>
<td>20 ± 6</td>
<td>17</td>
<td>51</td>
</tr>
</tbody>
</table>
US Rice Federation (2010)
Environmental Indicators Report

United States - Irrigation Water Applied per Hundred Weight of Rice Production

(Irrigation water)

1980’s
1990’s
2000’s
Averaged across all rice irrigation systems over the past 9 years, water use in MS has held steady at 36 ± 4 A-in/A per yr.

\[ y = 0.4x - 766.13 \]

\[ R^2 = 0.0958 \]
Irrigation Options for Mississippi Rice Producers
Irrigation Options for Mississippi Rice Producers

- Increase zero-grade acres

Total H₂O Requirements (ET + Soil Percolation) = ~14 to 25 A-in/A
Zero-Grade Rice Irrigation
Agronomic Issues Limit Adoption

Drawbacks of Zero-Grade Systems:

1. Water-logging of rotational crops, leading to continuous rice systems which can result in

2. Pest management issues (weed resistance; herbicide carry-over) and

3. Loss of yield bump associated with Soy-Rice Rotation
Estimated Adoption Rates for Rice Irrigation Systems in MS (2009)

- **Straight Levee + Side Inlet**: 20%
- **Zero-Grade**: 5%
- **Contour Levee**: 30%
- **Straight Levee**: 45%

Sources: MSU Extension Service grower surveys; rice consultant surveys; YMD permitting data.
Irrigation Options for Mississippi Rice Producers

• Increase zero-grade acres

• Sprinkler-irrigated rice
More stress-tolerant hybrids and improved herbicide programs may facilitate adoption.
Irrigation Options for Mississippi Rice Producers

• Increase zero-grade acres
• Sprinkler-irrigated rice
• Tailwater recovery systems and on-farm reservoirs
On-Farm Reservoirs & Tailwater Recovery Systems

- 16 A (93 A-ft) reservoir serving 300 crop acres near Metcalf, MS.
- 11 A-ft storage in tailwater recovery ditch
On-Farm Reservoirs & Tailwater Recovery Systems

Typical Construction Costs in 2011
(Trinity Long, NRCS-Greenwood, MS)

• $1 million (NRCS) + $300 K (grower) per section (640 A) of land, or

~ $2,000 per A (includes precision leveling, reservoir and tailwater ditch construction, underground piping, etc.)
White River Irrigation Diversion Project
(Carmen, 2011)

• Project cost: ~$450 million to irrigate 250,000 A (~$1,800 per A)

• Est. cost to deliver water to farm: ~$30 per A-ft

• Completion date: ? (depends on ~65% federal funding; once full funding received, water delivered to Stuttgart in 3 yrs.)
Irrigation Options for Mississippi Rice Producers

- Increase zero-grade acres
- Sprinkler-irrigated rice
- Tailwater recovery systems and on-farm reservoirs
- Drought-tolerant rice
Drought-Tolerant Rice
Bangladesh Rice Research Institute (2010)

Salient Features

- Drought tolerant at reproductive stage for T. Aman
- Plant height 115 cm
- Growth duration 106 days
- Golden coloured grain
- Grain Yield 4.0 t/ha

Drought-Tolerant Rice
Bangladesh Rice Research Institute (2010)

Salient Features
- Plant height 105 cm
- Growth duration 100 days
- Grain Jirasail & Minkit type
- Grain Yield 4.0 t/ha
- Can tolerate & escape terminal drought

Drought tolerant & escaping RLR Variety
- 70-80 cm Perch Water table
- <20% soil M.C.
- 8-10 rainless days

“The recent development of short-duration rice varieties and maize hybrids with improved drought tolerance is providing opportunities for the expansion of rice-maize systems into areas of South Asia with insufficient irrigation or rain for continuous rice cultivation.”

Timsina et al. (2011). Rice-maize systems in Asia: Current situation and potential.
Irrigation Options for Mississippi Rice Producers

• Increase zero-grade acres

• Sprinkler-irrigated rice

• Tailwater recovery systems and on-farm reservoirs

• Drought-tolerant rice

• Automated irrigation control systems
Remote Control of Irrigation Pump

*In Situ* Aquaculture Technology

Row Crop Applications?
Most Readily-Available Irrigation Option for the Majority of Mississippi Rice Acres?
Estimated Adoption Rates for Rice Irrigation Systems in MS (2009)

- **Zero-Grade**: 5%
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Sources: MSU Extension Service grower surveys; rice consultant surveys; YMD permitting data.
Multiple-Inlet Irrigation
in Straight-Levee Systems

Advantages of Side-Inlets:
• More rapid flood establishment.
• Reduced nitrogen loss.
• Improved herbicide activation.
• Greater control of flood.
• Facilitates adoption of other water-saving practices.

MAFES Publication No. 2338
Thomas et al. (2004)

Tacker (2010): Approximate cost = $12/A (tubing + labor)
Side-Inlet Irrigation Training Video
(Spring 2012)
Intermittent Flood Management to Increase Rainfall Capture & Reduce Over-Pumping

Avg. In-season rainfall ~10 to 14 inches

Flood Height (cm)

Days After Initial Flood

Continuous Flood

Drying Cycle 1

Drying Cycle 2

Drying Cycle 3

Less-than-Full Flood

Drying Cycle

Pumping Cycle:
~ 5 to 8 d

2-wk flood holding period

Avg. In-season rainfall ~10 to 14 inches
Average Water Use by Different MS Rice Irrigation Systems

- Coutour Levees: 44
- Straight Levee (SL): 38
- SL + Side Inlet: 31
- SL + Side Inlet + Intermittent: 22
- Zero Grade: 20
- Seasonal Rainfall: 15

9-yr average @ Dulaney Seed
Kline-2009 Field B
38 Acres, 8 paddies, Cocodrie, Sharkey Clay

Rice Yield: 190 bu/A (dry)
Avg. Milling Quality:
Not different top vs. bottom of paddies
Rainfall: 11 A-in/A
Water Pumped: 15 A-in/A
Total: 26 A-in/A
Electric cost: $40/A

2009 MS Rice Water Use (YMD, 2010)
State avg. = 37 A-in/A

Pringle (1996):
~14 to 25 A-in/A required by rice

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~14 to 25 A-in/A required by rice
2011 On-Farm Trials
Intermittent Rice Irrigation

Study 1: Varietal Response

- 8 Clearfield rice varieties using 4 reps per variety.

- Planted at the top (alternating wet-dry) and bottom (~continuous flood) of paddy.

- 150 lbs N per A applied.

- Yield and milling quality.

- Water use.
2011 On-Farm Trials
Intermittent Rice Irrigation

Study 2: Nitrogen Loss

- 1 Clearfield variety (CL162) planted at top and bottom of paddy.

- 6 Nitrogen rates (0 to 240 lbs/A) applied pre-flood using 4 reps each.

- Yield and milling quality.

- Water use.
2011 Intermittent Irrigation Trials
Kline 38-A field, clay soil

Water Pumped: 18 A-in/A

Top of Paddy: 8 wet-dry cycles

Sensor Depth (ft)

Drying Cycle No. 1 = 7 d

Red Line = Mud Exposed in Upper Paddy

Flood Initiation 04 June

Flood Termination 18 August
2011 Intermittent Irrigation Trials
Kline 38-A field, clay soil

Water Pumped: 18 A-in/A

Date/Time
Sensor Depth (ft)

Flood Initiation 04 June
Red Line = Mud Exposed in Upper Paddy

7.6-in rainfall

0.40" rain
0.84" rain
0.35" rain
1.05" rain

Flood Termination 18 August
Total H₂O Use = 7.6-in (rainfall) + 18-in (irrigation) = 25.6-in

2011 Intermittent Irrigation Trials
Kline 38-A field, clay soil
2011 Rice On-Farm Variety x Intermittent Irrigation Trials

N-rate = 150 lbs/A

Avg. Rice Yield (lbs/A)

Rice Variety

CL111  CL131  CL142  CL151  CL152  CL162  CL181  CLXL745

Top of Paddy  Bottom of Paddy
2010 Variety x Intermittent Irrigation Trial
Clay soil w/ 5 wet-drying cycles using 23 A-in/A
2010 Variety x Intermittent Irrigation Trial
Clay soil w/ 5 wet-drying cycles using 23 A-in/A

<table>
<thead>
<tr>
<th>Variety</th>
<th>Top of Paddy (int flood)</th>
<th>Bottom of Paddy (cont flood)</th>
<th>Type III Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice Yield (lb/A) dry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6004</td>
<td>10,548</td>
<td>9,067</td>
<td>0.0326</td>
</tr>
<tr>
<td>Bowman</td>
<td>9,838</td>
<td>9,905</td>
<td>0.9004</td>
</tr>
<tr>
<td>CL111</td>
<td>10,850</td>
<td>11,380</td>
<td>0.5048</td>
</tr>
<tr>
<td>CL131</td>
<td>10,850</td>
<td>11,380</td>
<td>0.5048</td>
</tr>
<tr>
<td>CL142</td>
<td>11,605</td>
<td>10,489</td>
<td>0.2304</td>
</tr>
<tr>
<td>CL181</td>
<td>9,588</td>
<td>9,278</td>
<td>0.6637</td>
</tr>
<tr>
<td>CLX745</td>
<td>12,386</td>
<td>11,698</td>
<td>0.1889</td>
</tr>
<tr>
<td>Cheniere</td>
<td>10,576</td>
<td>10,124</td>
<td>0.1017</td>
</tr>
<tr>
<td>Cocodrie</td>
<td>10,796</td>
<td>10,528</td>
<td>0.2154</td>
</tr>
<tr>
<td>Neptune</td>
<td>10,396</td>
<td>9,452</td>
<td>0.0756</td>
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<tr>
<td>Rex</td>
<td>10,481</td>
<td>9,899</td>
<td>0.1846</td>
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<tr>
<td>Taggart</td>
<td>11,486</td>
<td>10,961</td>
<td>0.3535</td>
</tr>
<tr>
<td>Templeton</td>
<td>11,083</td>
<td>9,933</td>
<td>0.0618</td>
</tr>
<tr>
<td>XL723</td>
<td>12,809</td>
<td>12,808</td>
<td>0.9986</td>
</tr>
</tbody>
</table>

No differences in grain yield or milling quality observed in 15 rice varieties when grown using intermittent flood (top of paddy) versus ~continuous flood (bottom of paddy).
Rice variety = CL162
Irrigation Options for Mississippi Rice Producers

- Increase zero-grade acres
- Sprinkler-irrigated rice
- Tailwater recovery systems and on-farm reservoirs
- Drought-tolerant rice
- Automated irrigation control systems
Multiple (Side) Inlet Irrigation is:

The most proven, cost-effective flood management tool currently available to MS growers.

Serves as a ‘foundation’ on which greater water and energy savings can be based.

Summary

2010 tubing + labor costs: ~$12/A (Tacker, 2010)

Takes a 3-person crew ~1 hour to install one roll of tubing incl. gates (J. Dulaney, 2011)
Intermittent Irrigation:

Extends water and energy savings of side-inlet with no additional cost.

Does not have to be fully adopted to reduce over-pumping and increase rainfall capture.

Can result in water and energy savings on par with that of Zero-Grade.

Every inch of water not pumped or captured as rainfall saves ~ 0.7 gal diesel per A.
Systematic Approach to Water Conservation

- Crop Breeding
- Agronomic Management
- Economics
- State/Federal Regulations
- Irrigation Technology
Thank you!
Kline-2009 Field B
38 Acres, 8 paddies, Cocodrie, Sharkey Clay
Estimated Adoption Rates for Rice Irrigation Systems in MS (2009)

- **Zero-Grade**: 5%
- **Contour Levee**: 30%
- **Straight Levee + Side Inlet**: 20%
- **Straight Levee**: 45%

- 15% savings (~93,000 A-ft) forZero-Grade
- 15% savings (~38,000 A-ft) for Contour Levee
- 130,000 A-ft savings for Straight Levee

Sources: MSU Extension Service grower surveys; rice consultants