Field-integrated flux measurements in Mid-South US rice using eddy covariance: findings and innovations

5th Paddy Rice Research America Sub-group
Global Research alliance on Agricultural Greenhouse Gases
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USDA-ARS-Delta Water Management Research Unit[1] and University of Arkansas[2]

Motivation

- Delta Water Management Research Unit
  - Water quantity and quality
  - Greenhouse gas emissions
    - LMRB 75% US rice
- Field-scale
- Outline
  - Irrigation water management
  - Winter management
  - Chamber vs EC
  - Co-benefits

US rice Irrigation-water use

MIRI = Multiple Inlet Rice Irrigation

Network of Systems

- Progression of systems
  - 2012: CO_2, H_2O growth staging
  - 2013-2016: DF vs AWD; Added methane
  - 2017-2018: DF, AWD, vs ROW
  - 2019-2020: Rice/Soybean + WQ; ROW, ROW + CC, vs DF
  - 2021-2022: Rice/Soybean + WQ; Added nitrous oxide
- Systems
  - 2012-2018/2020 production season
  - 2018-present annual evaluation
- Paired with water quality sensing

Objective

Determine the Influence of irrigation management on field-scale measurements of greenhouse gas emissions with current varieties under typical production practices.

US rice irrigation-Alternate Wetting and Drying

Benefits

- Reduce arsenic
- Reduce water use
- Reduce greenhouse gas emissions
- Potential for offset with carbon credit

Potential challenges

- Increase management requirements
- Weed pressure
- Potential to impact yield

Publ

The Economic Viability
Irrigation in

Lanier Nalley,* Bruce

ABSTRACT

As water becomes scarcer in rice (*Oryza sativa* L.) p

Field Crops Research 170 (2015) 95–108

Contents lists avail

Field Crop

ELSEVIER

journal homepage: ww

Review

Adoption and economics of alternate we
management for irrigated lowland rice

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Publisl

Climatology & Water Management

Rice Water Use Efficier
and Inter

Luis Antonio de Avila,* Luiz Fernando D. Marti
Diogo M. Cezimbra, Sérgio Luis O. Machado

ABSTRACT

In the Brazilian state of Rio Grande do Sul, rice (*Oryz*

Global Change Biology

Global Change Biology (2014), doi: 10.1111/gcb.12708

Reducing greenhouse gas emissions, water use, and grain arsenic levels in rice systems

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Abstract

Agriculture is faced with the challenge of providing healthy food for a growing population at minimal environmental

Plot plan

- 16 16.2-ha (40-ac) fields
  - 0.1% slope
  - 4-blocks of 4 treatments
  - Each block w/ well
- Treatments
  - Row
  - Cascade
  - MIRI
  - MIRI + AWD
- Rotated all treatments clockwise except ROW in 2018

ield reatment	2017	2018
ontinuous lood/ MIRI	42.7	16.2
AWD	28.8	13.3
Reduction	-48%	-18%

Dry Downs
2017: -43%
2018: -39%

ROW methane emissions 2018

Field Treatment	2018	Reduction
Continuous Flood/ MIRI	16.2	
AWD	13.3	-18%
ROW	11.8	-27%

Grain quality

- Milled (73%) & head rice (59%) yield not affected by irrigation treatment
- Pasting properties
  - Peak and breakdown viscosity not affected ($p > 0.05$)
  - Setback viscosity (cooked rice texture) lower (146 cP vs 168-169 cP)
- Chalkiness
  - Slightly higher in AWD (5.6% vs 5.1-5.2%)

Graham-Acquaah, S., T. Siebenmorgen, **M.L. Reba**, J.H. Massey, A. Mauromoustakos, A. Adviento-Borbe, R. January, R. Burgos, and J. Baltz-Gray. Impact of alternative irrigation practices on rice quality. Cereal Chemistry. Vol. 96, 815-823. doi:10.1002/cche.10182. 2019.

Field scale water management study: Results

Study synthesis

- Methane reduction 18-48% MIRI to AWD, 27% MIRI to ROW (2018)
- Grain quality sustained
- Arsenic-low but reduced

- Collaboration
  - Florenden Farm
  - University of Arkansas
    - Benjamin Runkle
    - Terry Siebenmorgan

Flood for waterfowl

- Flyway & wintering for migratory birds
- Flood vs non-flood

Reba, M.L., *B. Fong, I. Rijal*. Fallow season CO_2 and CH_4 fluxes from US mid-south rice-waterfowl habitats. *Agricultural and Forest Meteorology*. Vol. 279. 107709. https://doi.org/10.1016/j.agrformet.2019.107709. 2019.

Timeline

Production Season				Harvest/ Land Prep		Winter Flooding			Land Prep/Planting		
May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr

Study synthesis

- Winter flooding is a common practice in the mid-south
- Three seasons study in NE Arkansas
- Three-year season GWP (CO_2 & CH_4) not different by treatment
- Regardless of treatment CH_4 emissions during the winter accounted for 16 to 27% of growing season emissions.

Year	Non-flooded			Flooded		
	Growing season (kg CH_4-C ha^{-1} $season^{-1}$)	Winter (kg CH_4-C ha^{-1} $season^{-1}$)	% growing season	Growing season (kg CH_4-C ha^{-1} $season^{-1}$)	Winter (kg CH_4-C ha^{-1} $season^{-1}$)	% growing season
2015	36.1*	6.0	17%	37.6	8.8	23%
2016	40.4	10.8	27%	97.3	15.9	16%
2017	--	9.1	--	--	12.8	--
Average	38.3±2.2	8.6±1.4		67.5±29.9	12.5±2.1	

EC vs static flux chambers

- 2015 & 2016
- Daily fluxes were similar
- Total seasonal flux higher SFC
- Early season & late season similar
- Mid-season differ ($p < 0.001$)
  - Tillering through reproductive

Reba, M.L., *B. Fong, I. Rijal*, M.A.A. Adviento-Borbe, Y. Chiu, and J. Massey. Methane flux measurement in rice by static flux chamber and eddy covariance. *Agrosystems, Geosciences & Environment.* Vol 3 (1), e20119. https://doi.org/10.1002/agg2.20119. 2020.

Future research

- N_2O sensor deployed 2022
- Update to USDA-Quantifying Greenhouse Gas Sources and Sinks in Cropland and Grazing Land Systems
  - Tier 2 methodology (Linquist et al., 2018)
- Annual emissions soybean/rice rotation
- Relate emissions measurements with measurements of runoff water quality

Thank you!

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