Rice GHG Emissions under varied Nitrogen, Variety, and Water Management

PAST – WORK
PRESENT – CHALANGES
FUTURE - NEEDS

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PLANTS

DON'T

LIE

V. 2.4

Nitrogen fertility

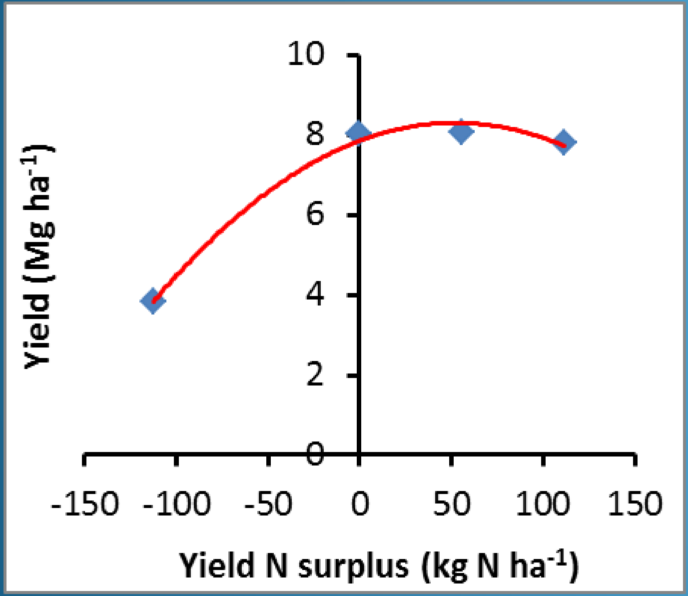
CLXL 745

Rates: 0, 112, 168, 224 kg N ha^{-1} as Urea; single pre-flood

kg N ha^{-1}	kg CH_4-C ha^{-1}	kg CO_2 eq ha^{-1}	g N_2O-N ha^{-1}	kg CO_2 eq ha^{-1}	% Fert. Emis.
112	41 a	1375 a	69 bc	33 bc	0.037
168	46 a	1550 a	161 b	76 b	0.080
224	40 a	1336 a	336 a	157 a	0.138

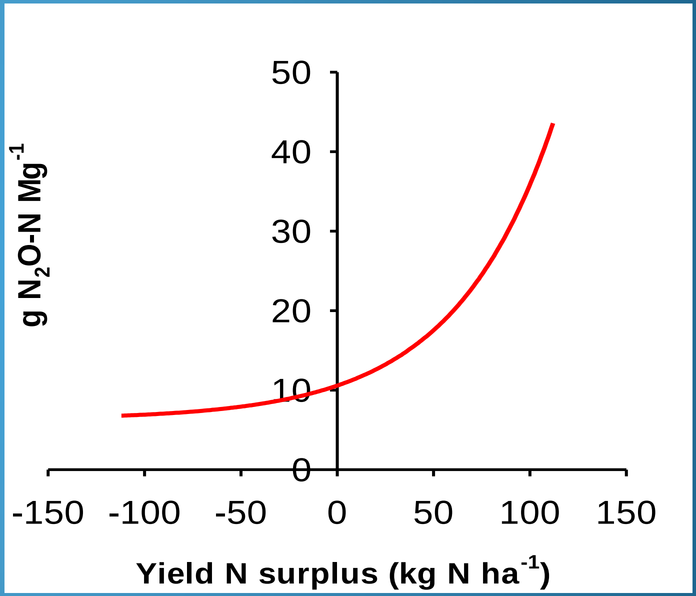
Nitrogen fertility

Rice yields



112 kg N ha^{-1}

N_2O emissions



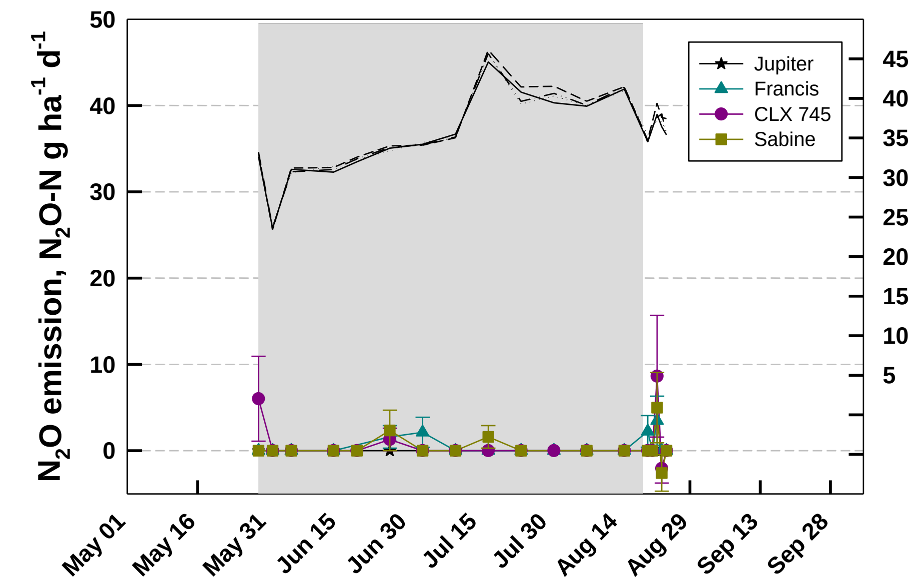
Adviento-Borbe, M.A., C.M. Pittelkow, M. Anders, C. Van Kessel, J.E. Hill, A.M. McClung, J. Six, and B.A. Linquist. 2013. Optimal fertilizer nitrogen rates and yield-scaled global warming potential in drill seeded rice. J. Evron. Qual., 42:6: 1623-1634.

Variety

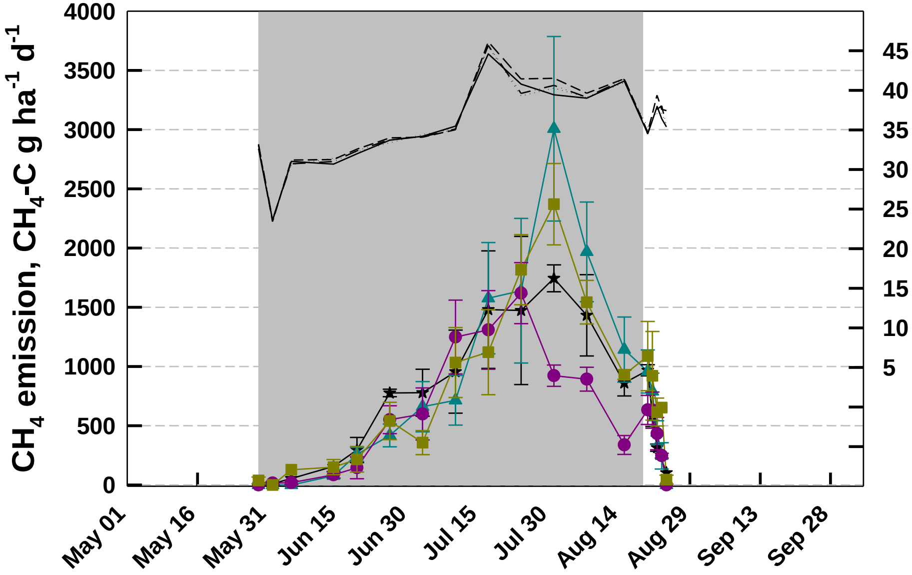
Rice Variety	Total CH_4 emissions g CH_4-C ha^{-1} $season^{-1}$	Total N_2O emissions g N_2O-N ha^{-1} $season^{-1}$	GWP kg CO_2 eq ha^{-1} $season^{-1}$	Grain Yield Mg ha^{-1}	Yield-scaled GWP kg CO_2 eq Mg^{-1} $season^{-1}$
CLXL 745	52874	20	1775	9.52	186
Jupiter	70411	0	2351	8.18	287
Sabine	64499	26	2166	6.17	351
Francis	80980	23	2715	7.39	368

Simmonds, M., M. Anders, M.A. Adviento-Bore, C. van Kessel, A. McClung, B. Linquist. 2015. Seasonal methane and nitrous oxide emissions of several rice cultivars in direct-seeded systems. J. Environ. Qual., 44:103-114.

Variety



Jupiter
Francis
CLX 745
Sabine
N_2O emission, N_2O-N g ha^{-1} d^{-1}
May 01
May 16
May 31
Jun 15
Jun 30
Jul 15
Jul 30
Aug 14
Aug 29
Sep 13
Sep 28



CH_4 emission, CH_4-C g ha^{-1} d^{-1}
May 01
May 16
May 31
Jun 15
Jun 30
Jul 15
Jul 30
Aug 14
Aug 29
Sep 13
Sep 28

Water

Study design and data collection

1. **Location: Rice Research and Extension Center, Stuttgart AR**
   a. DeWitt Silty Clay Loam soil (fine, smectitic, thermic, Typic Albaqualf)
   b. pH 5.6-6.2, Carbon 8.4g C kg^{-1} soil, Nitrogen 0.6 g N kg^{-1} soil

2. **Four replications with 4 water treatments one hybrid (CLXL745)**
   a. Flood, AWD/40-flood, AWD/60, AWD/40
   b. AWD = alternate wetting and drying; /value= percent of saturated soil
   c. AWD/40-flood changed at R1-R2; Dynamax probe used
   d. Field flooded to 10-cm, natural dry, soil moisture determined when field "dry"
   e. Moisture measurements made to 50-mm; 4 $plot^{-1}$; averaged across reps.
   f. N rate of 134 kg ha^{-1} on all treatments as pre-flood (15-20 day hold)
   g. Irrigation water measured with McCrometer flow meter

3. **GHG measurements using 30.48-cm static vented chamber technique**
   a. Collected at 0, 20, 40, 60-min intervals
   b. Frequency dictated by field management activities and weather

Results for grain yield

2012 ,2013 rice soybean
2013 continuous rice

	Rice grain yields (Mg ha^{-1})			
Water treatment	2012-RS	2013-RS	2013-RR	Mean
Flood	9.78 *a*	11.15 *a*	9.84 *a*	**10.26 *a***
AWD/40 – Flood	9.27 *a*	11.15 *a*	10.33 *a*	**10.17 *ab***
AWD/60	9.22 *a*	10.37 *b*	9.61 *a*	**9.73 *b***
AWD/40	9.03 *a*	9.58 *c*	8.31 *b*	**8.97 *c***

Results for water use

2012 ,2013 rice soybean
2013 continuous rice

Irrigation water use (m^3 ha^{-1}) water use efficiency (WUE = kg rice/m^3)

Water treatment	2012-RS Use	2012-RS WUE	2013-RS Use	2013-RS WUE	2013-RR Use	2013-RR WUE	Mean Use	Mean WUE
Flood	7617 (718)	1.28	7617 (1077)	1.46	8582	1.15	**7939**	**1.30**
AWD/40 – Flood	6602 (359)	1.40	6475 (538)	1.72	6459	1.60	**6512**	**1.58**
AWD/60	6475 (180)	1.42	5840 (0)	1.78	4040	2.38	**5452**	**1.86**
AWD/40	5078 (359)	1.78	5205 (180)	1.84	3030	2.74	**4438**	**2.12**

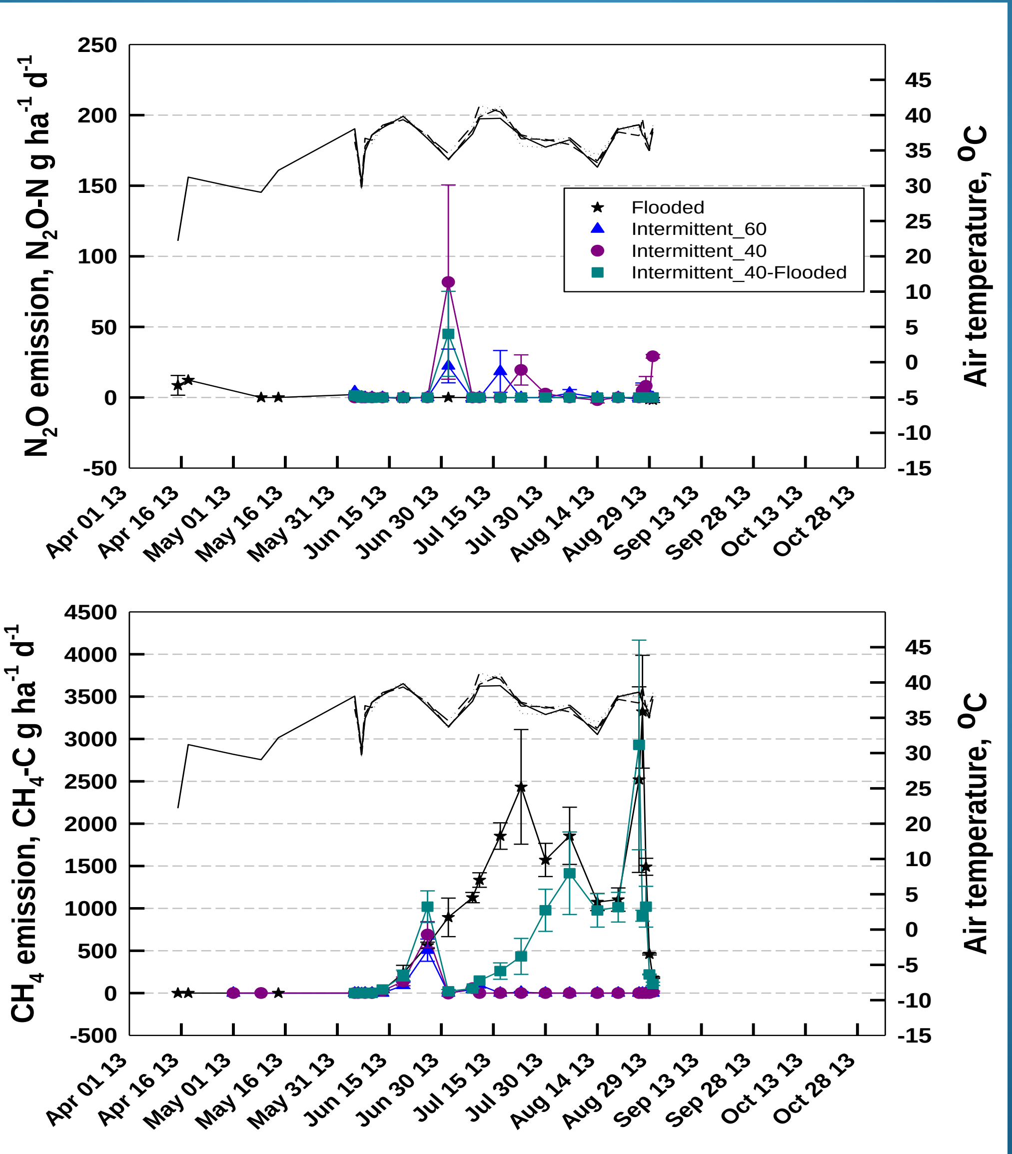
Results for gas emissions

2012 ,2013 rice soybean
2013 continuous rice

Water management	CH_4	N_2O	GWP	
	kg CH_4-C ha^{-1}	kg N_2O-N ha^{-1}	kg CO_2 eq ha^{-1}	kg CO_2 eq Mg^{-1}
		2012 Rice-soybean		
Flood	71.0 *a*	0.031 a	2385 *a*	**249 *a***
AWD/40–flood	37.2 *b*	0.104 b	1292 *b*	**145 *b***
AWD/60	2.8 *c*	0.229 c	201 *c*	**23 *c***
AWD/40	1.7 *c*	0.137 b	120 *c*	**14 *c***
		2013 Rice-soybean		
Flood	100 *a*	0.07 *b*	3371 *a*	**301 a**
AWD/40–flood	56.7 *b*	0.39 *a*	2076 *b*	**181 b**
AWD/60	6.04 *c*	0.40 *a*	389 *c*	**36 c**
AWD/40	7.80 *c*	1.05 *a*	751 *c*	**72 c**
		2013 Rice-rice		
Flood	144 *a*	-0.008 *b*	4804 *a*	**476 a**
AWD/40–flood	71.4 *b*	0.028 *b*	2397 *b*	**235 b**
AWD/60	11.8 *c*	0.198 *ab*	486 *c*	**50 c**
AWD/40	13.7 *c*	0.329 *a*	611 *c*	**69 c**

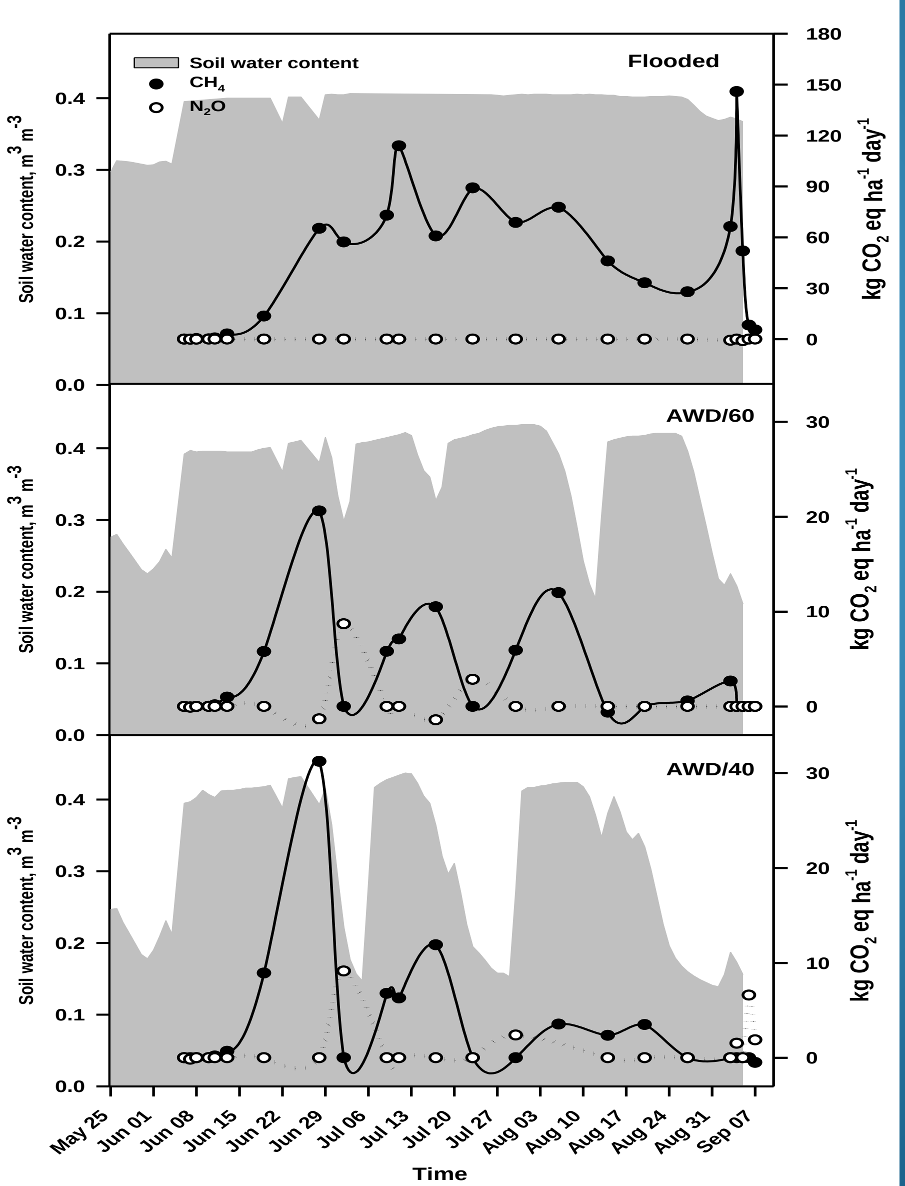
Results for gas emissions

2013 rice soybean



Results for gas emissions

2013 rice soybean



Results

1. **Water use efficiency improved 18 to 63%**
2. **GHG emissions reduced by 48 to 63%**
3. **Arsenic reduced by 63%**
4. **GHG emission levels less than reported for corn or wheat**
5. **Nitrogen efficiency was not reduced**
6. **Rotation differences in GHG were evident**
7. **Adoption determined by cost savings and carbon market**

Linquist, B.A., M. Anders, M.A. Adviento-Bore, R.L. Chaney, L.L. Nalley, E. da Rosa, and C. van Kessel. 2014. Reducing greenhouse gas emissions, water use and grain arsenic levels in rice systems. Global Change Biology, doi: 10.1111/gcb.12701.

Results

Farmer adaptation of intermittent flooding using multiple-inlet rice irrigation in Mississippi

Joseph H. Massey a,∗, Tim W. Walker a, Merle M. Anders b, M. Cade Smitha, Luis A. Avila c

http://dx.doi.org/10.1016/j.agwat.2014.08.023 0378-3774/Published by Elsevier B.V.

The Economic Viability of Alternative Wetting and Drying Irrigation in Arkansas Rice Production

Lanier Nalley,* Bruce Lindquist, Kent Kovacs, and Merle Anders

Published in Agron. J. 107:1–9 (2015) doi:10.2134/agronj14.0468

Impact of production practices on physicochemical properties of rice grain quality

Rolfe J Bryant,a∗ Merle Andersb and Anna McClunga

(wileyonlinelibrary.com) DOI 10.1002/jsfa.4608

Results

Nitrogen uptake under alternate wetting and drying water management

Anders, M.M. et al.

Water management impacts rice methylmercury and the soil microbiome

Sarah E. Rothenberga,*, Merle Andersb, Nadim J. Ajamic, Joseph F. Petrosinoc, Erika Baloghd

Accepted Science of the Total Environment

The influence of water management on arsenic uptake in rice grain and aquaporin expression in rice roots

Sarah E. Rothenberg a,*, Merle Anders b, Leah B. Schmalfuss a, Erika Balogh c, William J. Jones a, Brian Jackson d

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Rice grain yield and quality when grown under limited water conditions.

Anders, M.M., R.J. Bryant, K.M. Yeater, S. Brooks, and A. M. McClung.

Moving forward?

WHAT DO WE KNOW: VERY LITTLE (LESS)

GENETICS:

1. Mechanisms of methane production?
2. Improved drought stress and associated traits?

NUMBER 1 WILL NEVER RESULT IN INCREASED WATER

INVENTORY OF GHG EMISSIONS IN MAJOR VARIETIES/HYBRIDS

Moving forward?

SCALE RESULTS TO COMMERCIAL FIELDS

MANAGEMENT:

1. How dry do we need to be?
2. When do we need to be drier or wetter?
3. How do we measure soil moisture for management?
4. GHG emission levels in row rice?
5. Added N_2O measurements to field scale measurements?
6. Include other disciplines such as microbiologists?

RCPP, Climate Change Initiative, NRCS changes

http://www.sustainablerice.org/

QUESTIONS