Non-continuous flooding practice and hybrid rice further reduce GHG emissions in irrigated drill seeded systems

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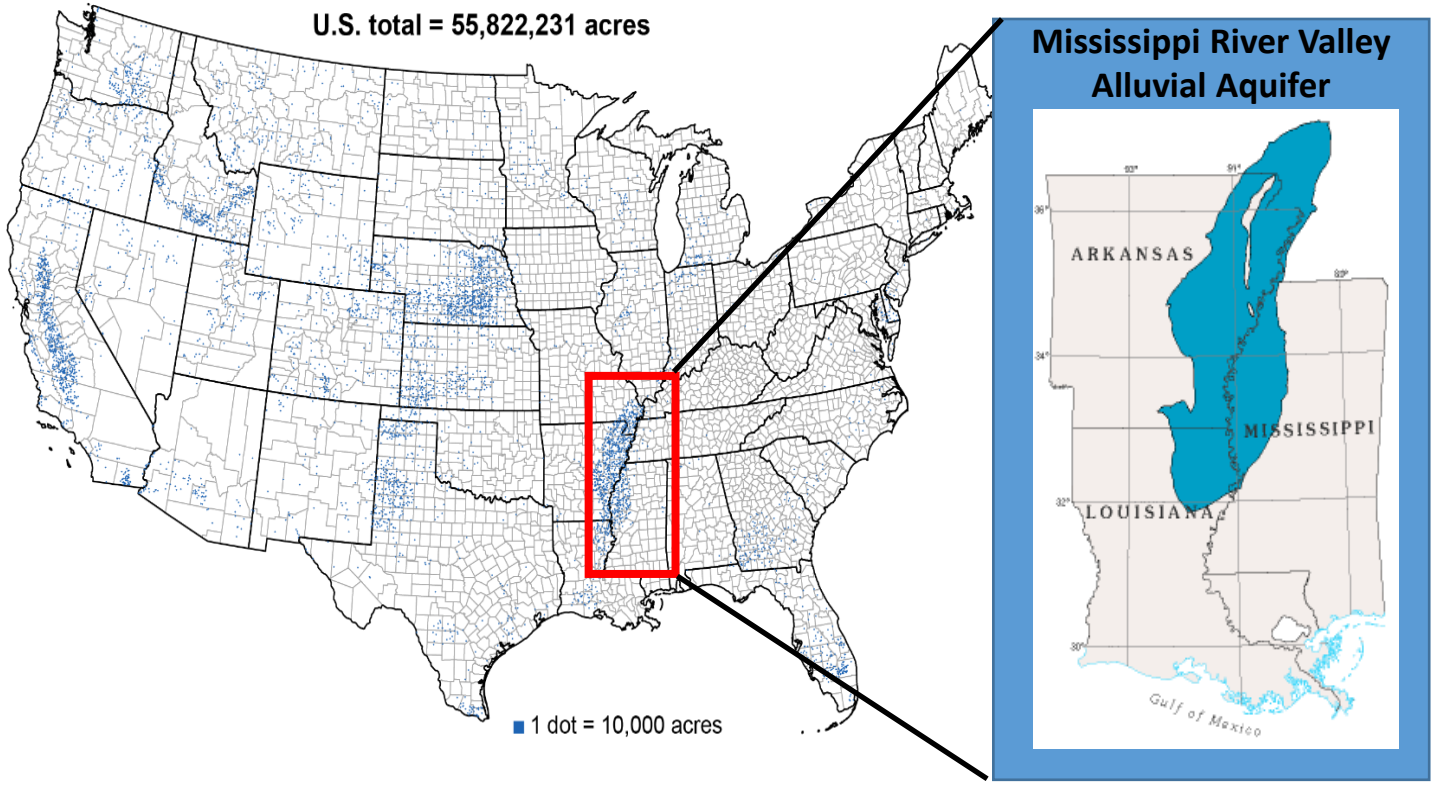
Declining groundwater in the Mississippi River Delta region



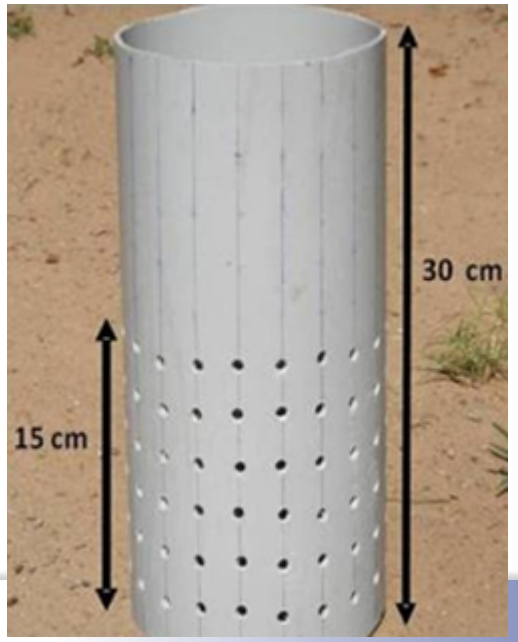
- Arkansas is third in the US for irrigated areas.
- Mississippi River Valley Alluvial Aquifer (MRVAA) is the primary source of irrigation water (≥80%) .
- Rice production in Arkansas relies heavily on irrigation.
- Rice accounts for about half of groundwater use.
- Rice receives about 3 times the irrigation that is applied to maize and soybean.

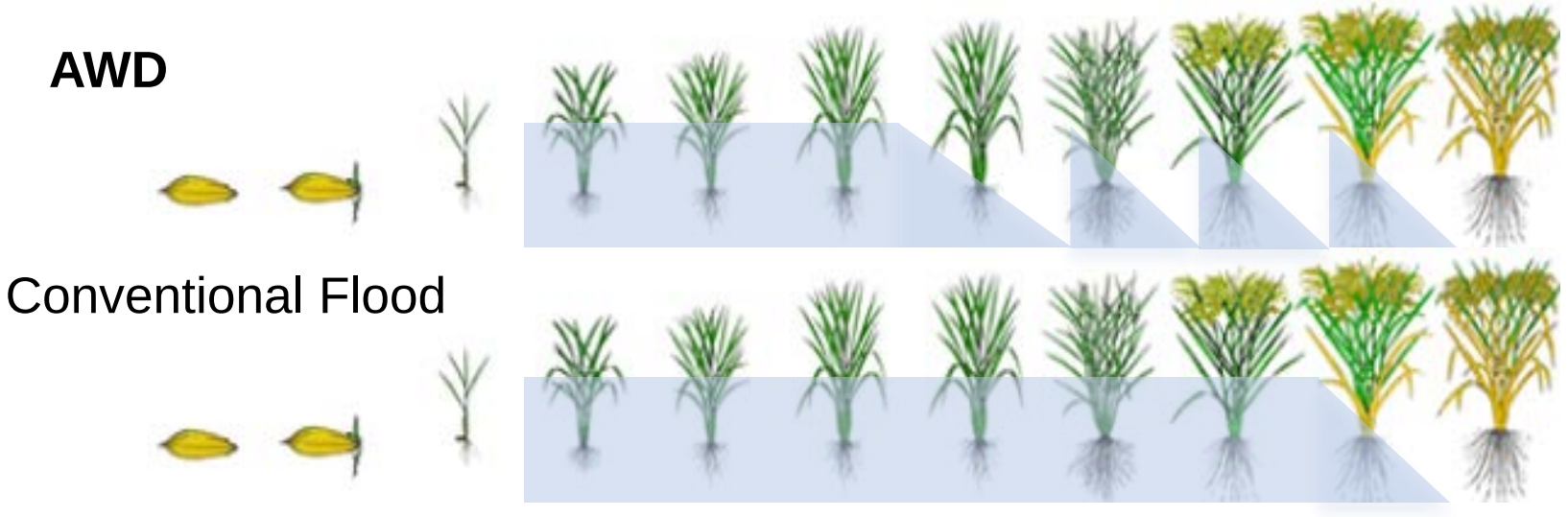
Irrigation applied to rice using various irrigation methods in Mississippi Delta

Rice Irrigation Practice	Irrigation applied,	% Difference from Conventional Practice
	mm	*%*
Continuously Flooded – *Cascade*[1]		
Contour-Levee[1]	1037	
Straight – Levee[1]	981	-5
Straight – Levee and Multiple Inlet Rice Irrigation, *MIRI*[1]	795	-23
Zero-grade, 0% slope[1]	574	-45
MIRI and Alternate wetting and drying, *AWD*[2]	696	-33
Furrow Rice, *ROW*[2]	632	-39

[1] *Source: Massey et al. 2013, Irrigation Sci J , doi: 10.1007/s00271-017-0543-y*
[2] *Source: Unpublished DWMRU data*

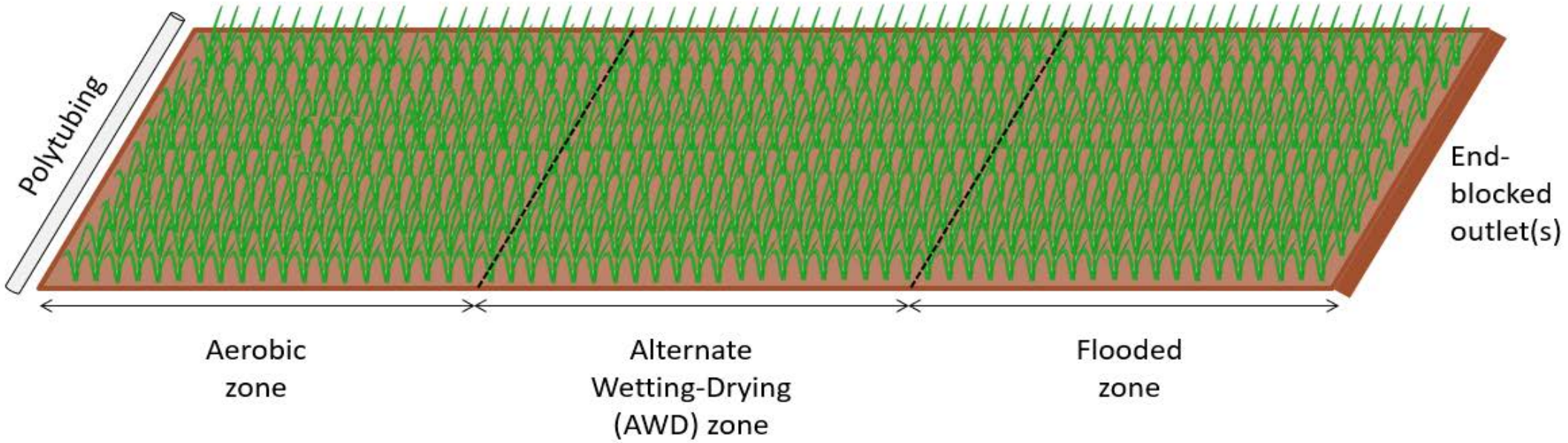
Improved irrigation management practice: Alternate wetting and drying (AWD)





- First developed at IRRI to address water scarcity.
- Field tested and validated by rice farmers in Bangladesh, Indonesia, Lao PDR, Philippines, Myanmar and Vietnam.
- AWD consists of flooding a field to a reasonable depth and allowing the flood to subside naturally via infiltration and evapotranspiration
- The practice reduces water use by up to 30% and CH_4 emissions by 48 – 93%.

Improved irrigation management practice: Furrow rice irrigation (Row rice)



- Rice grown on raised beds separated by furrow
- Creates three soil moisture zones that impact
  - Rice agronomics
  - Fertilizer nitrogen application
  - Weed management.
- Reduce labor and irrigation costs

Multiple benefits of using non-continuous flooding practice

- Improve irrigation use efficiencies
- Reduce methane production
- Reduce arsenic in the grain
- Reduce farm input costs to farmers

Challenges of non-continuous flooding practice

- Adoption in commercial rice systems
  - Yield reductions
  - Labor requirement
  - Timing
- Soil water content limit for re-flooding
  - Save AWD - Floodwater level at 10 cm below soil surface
  - Mud state
  - Severe AWD – beyond -20 kPa water condition

Low-emitting rice cultivars for mitigating GHG emissions

- The hybrid CLXL745 has shown to emit less CH_4 than do other cultivars in different locations and conditions.
- Cultivar differences were related to plant growth and morphological characteristics (transport capacity)
- Current reports suggest root microbiome of high CH_4 emitting cultivar is enriched both in methanogens and in taxa associated with processes that support methanogenesis *i.e.* fermentation, Fe, sulfate reduction and acetogenesis
- The real influence of cultivar differences is still unknown.

Objectives

1. Determine differences in seasonal CH_4 and N_2O emissions among commonly grown hybrid and inbred rice cultivar in Arkansas,

2. Quantify global warming potential (GWP) and yield-scaled GWP (GWP_Y) of rice cultivars managed under continuously flooded and alternate wetting & drying (AWD) practice.

3. Assess grain yields of different cultivars under non-continuous flooding irrigation.

Field experiments and methods

1. Alternate wetting and drying practice (AWD) and hybrid rice in irrigated drill seeded system for reducing greenhouse gas emissions

Funding Source: RICETEC, Inc

Treatments:

- 1 Inbred (CLL15 and 3 hybrid cultivars (CLXL745, XP760, XP753)
- AWD vs. Continuously Flooded

Seeding system:

- Drill seeded

N fertilizer rate:

- 134 kg N ha^{-1}

Measurements:

- CH_4, CO_2, and N_2O emissions using flux chamber method with gas chromatography
- Grain Yield, yield components

Location of field trial

- RiceTec Research Farm, Harrisburg, Arkansas USA

Field experiments and methods

2. Furrow rice irrigation and hybrid rice in drill seeded system for reducing greenhouse gas emissions

Funding Source: RICETEC, Inc

Treatments:

- 1 Inbred (CLL15) and 3 hybrid cultivars (RT7521, RT7321-Yara, RT7321-Cruiser)
- AWD vs. Continuously Flooded

Seeding system:

- Drill seeded

N fertilizer rate:

- 224 kg N ha^{-1}

Measurements:

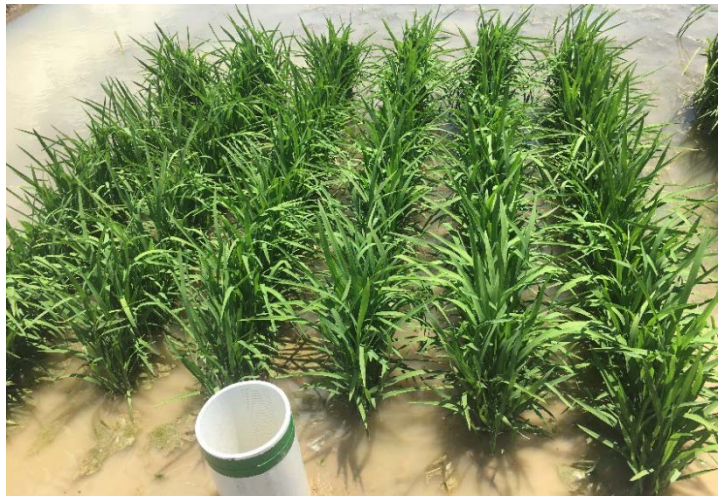
- CH_4, CO_2, and N_2O emissions using flux chamber method with gas chromatography
- Grain Yield, yield components
- Water use
- Grain quality:
  - Heavy metals i.e. **As**, **Cd**, **Hg, Pb**
  - Elemental nutrients; **Se**, P, K, Ca, Mg, Fe, Mn, Mo,

Location of field trial

- Northeast Rice Research Center University of Arkansas Division of Agriculture, Harrisburg, Arkansas USA

Field experiments and methods

3. Understand the impacts of alternate wetting and drying irrigation on CH_4 and N_2O emissions and crop performance in selected rice cultivars



Treatments:

- Francis, Lemont, TL448, TL654
- AWD vs. Continuously Flooded

Seeding system:

- Drill seeded

N fertilizer rate:

- 168 kg N ha^{-1}

Measurements:

- CH_4 and N_2O emissions using flux chamber method with gas chromatography
- Grain Yield

Location of field trial

- Dale Bumpers Rice Research Center, Stuttgart, Arkansas, USA

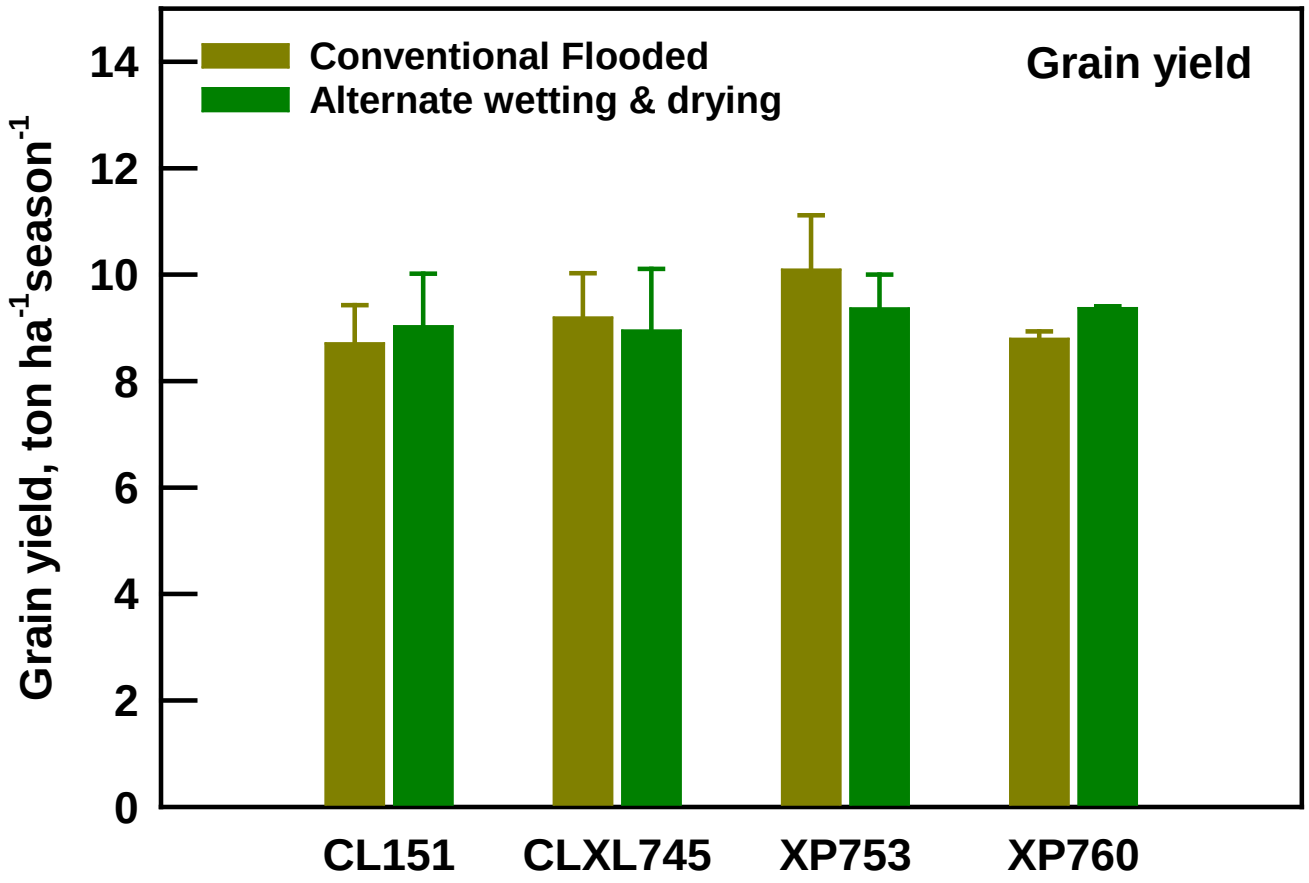
Measurements of field CH_4 and N_2O emissions

- 30.5 cm diameter vented flux chamber with 17 CFM/5800 RPM fan
- daily to weekly gas sampling

- varying chamber height (13 - 122 cm; 8-90 L) based on height of growing rice

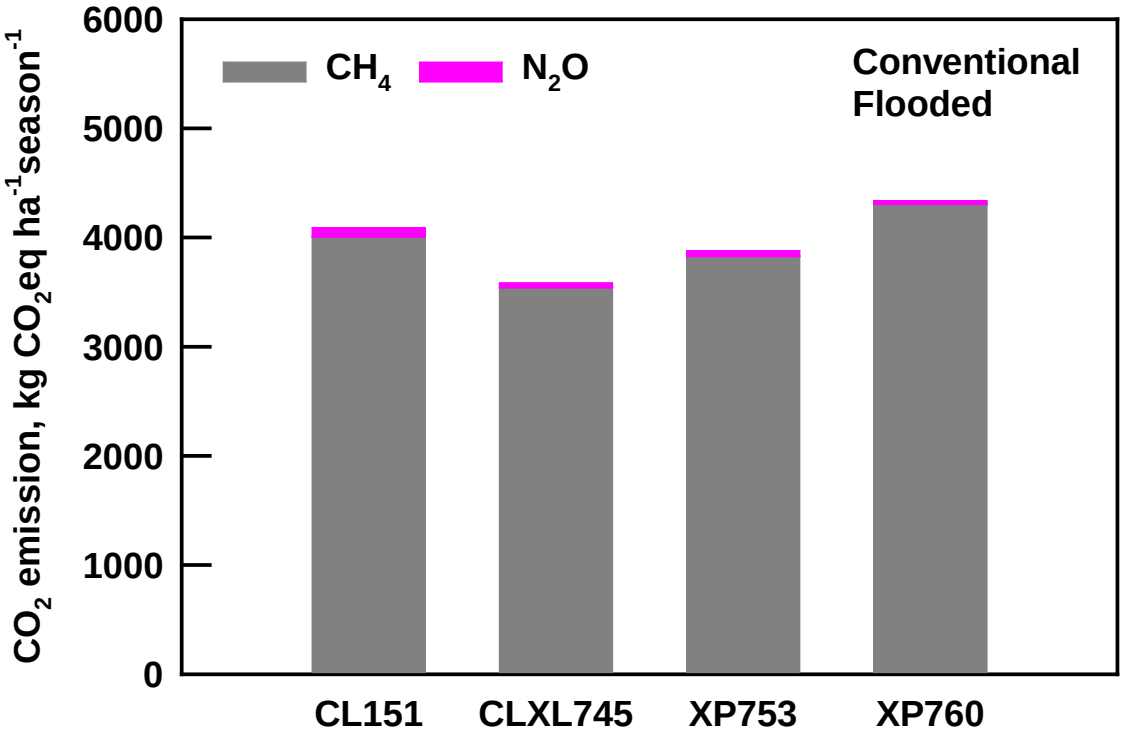
- Multi-point valves GC-2014 gas chromatograph with a ^{63}NI ECD , TCD, and FID detectors

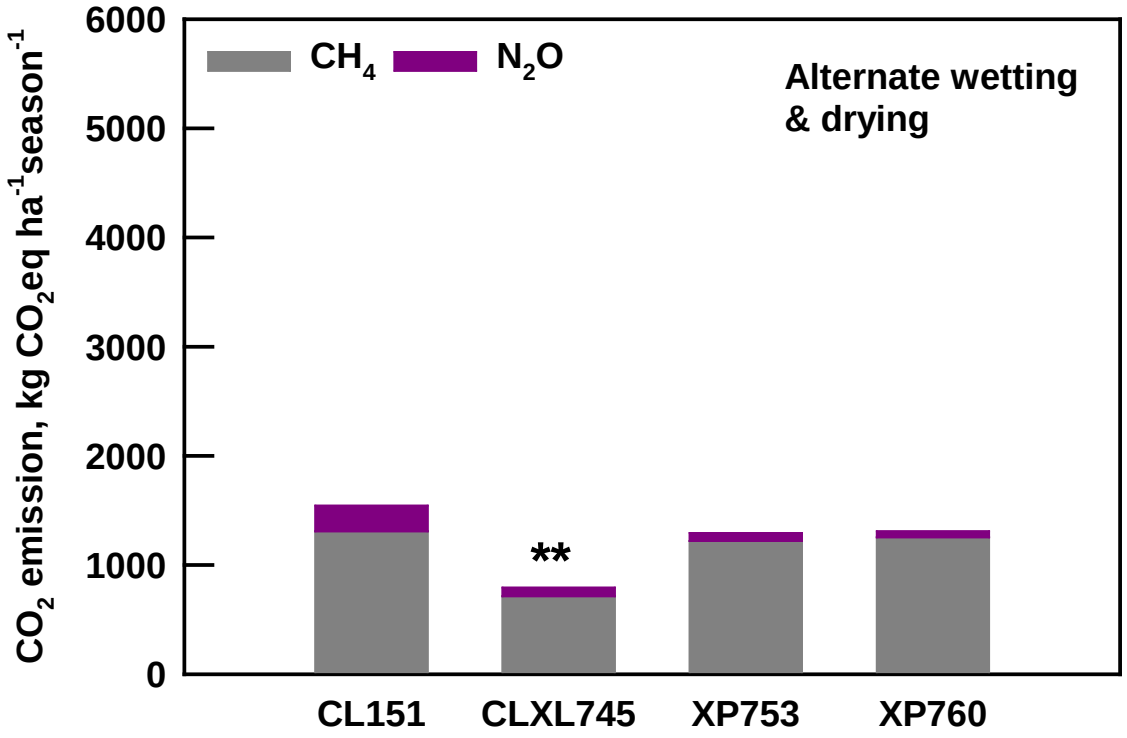
Field study 1: Alternate wetting and drying practice (AWD) and hybrid rice in irrigated drill seeded system for reducing greenhouse gas emissions



- ***No grain yield loss in AWD irrigation and hybrid cropping.***

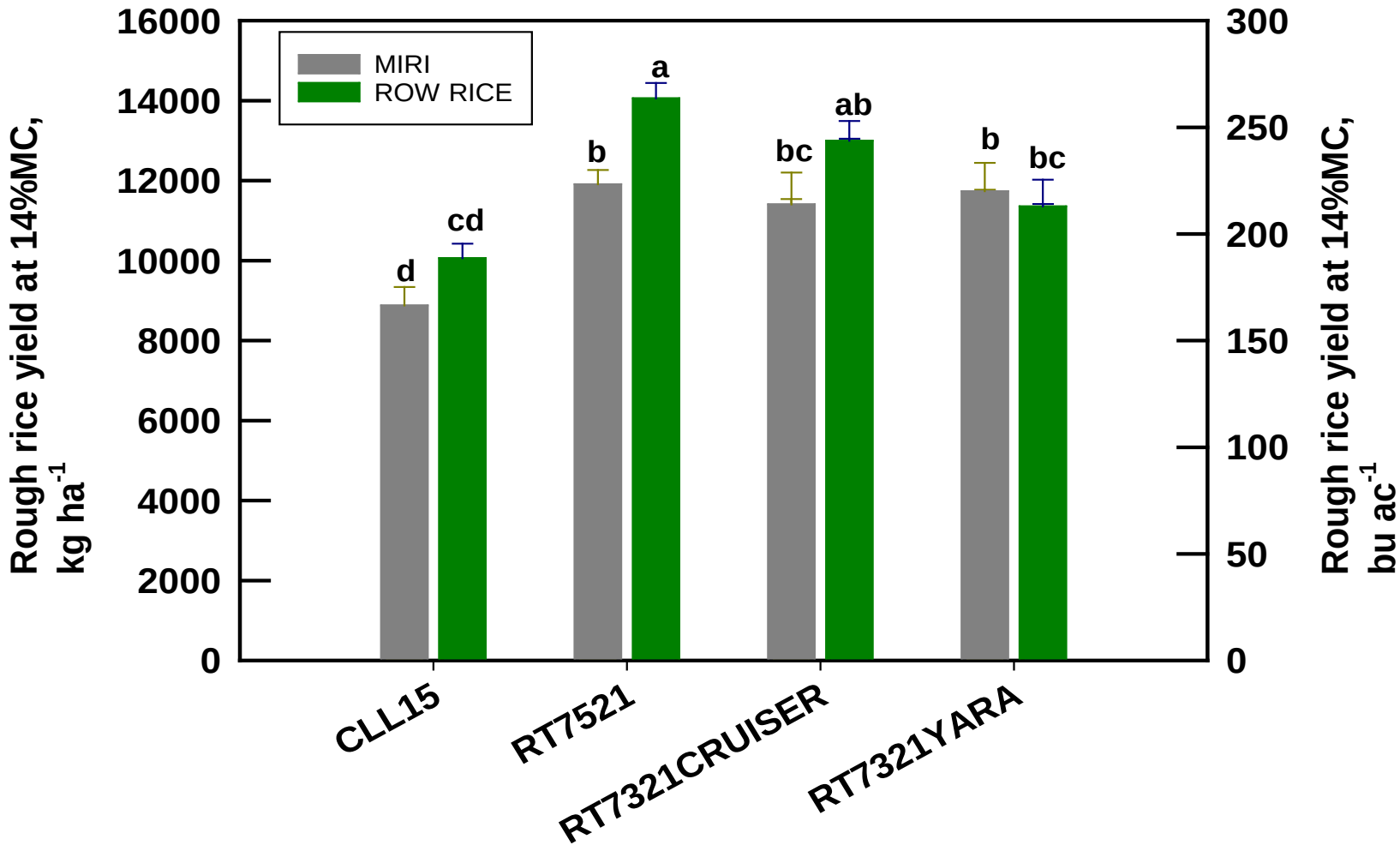
Field study 1: Alternate wetting and drying practice (AWD) and hybrid rice in irrigated drill seeded system for reducing greenhouse gas emissions





- ***AWD irrigation and hybrid variety reduced CH_4 emissions by 56% but N_2O emissions increased by 57% relative to conventional practice.***
- ***Overall, AWD and the use of some hybrid varieties decreased Global warming potential by 73%.***

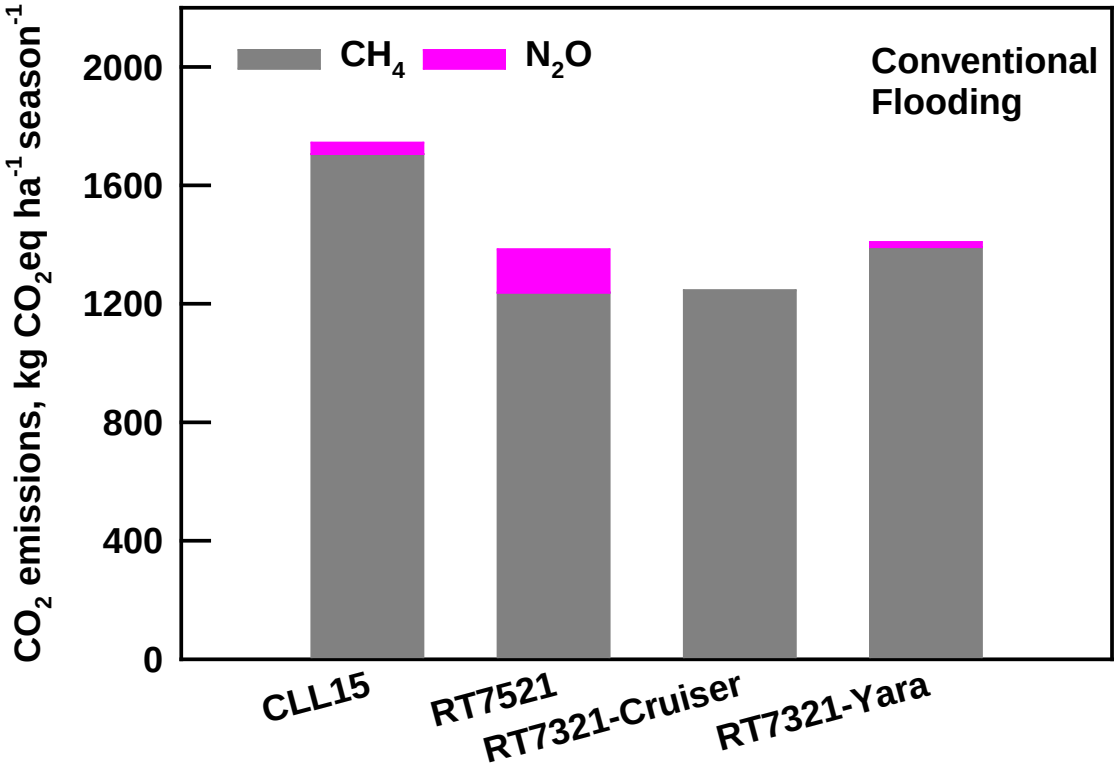
Field study 2: Furrow rice irrigation and hybrid rice in drill seeded system for reducing greenhouse gas emissions

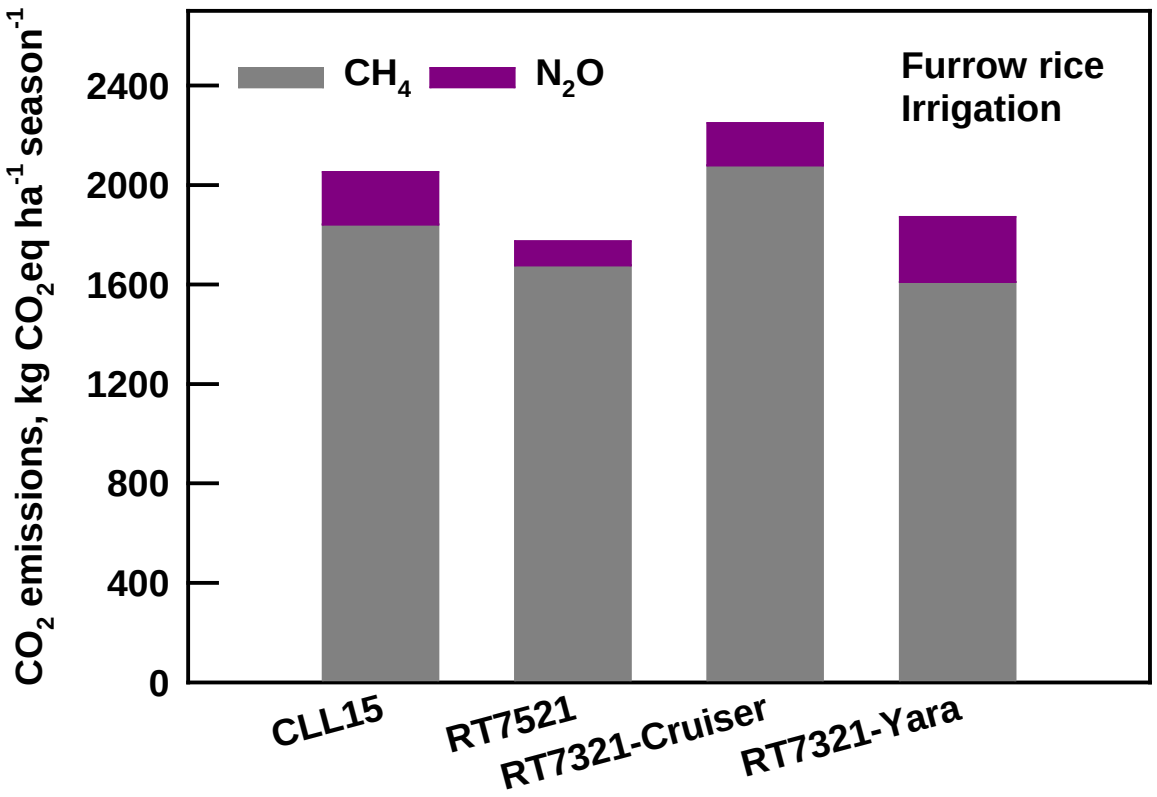


- *RT7521 and RT7321 Cruiser performed better in furrow irrigation*
- *Yields of CLL15 were the same in MIRI and Furrow rice*

Mean grain yield in the four rice varieties and various irrigation treatments. Standard errors were calculated based on 9 replicates. Grain yields with similar letters are not significantly different at P-level <0.05.

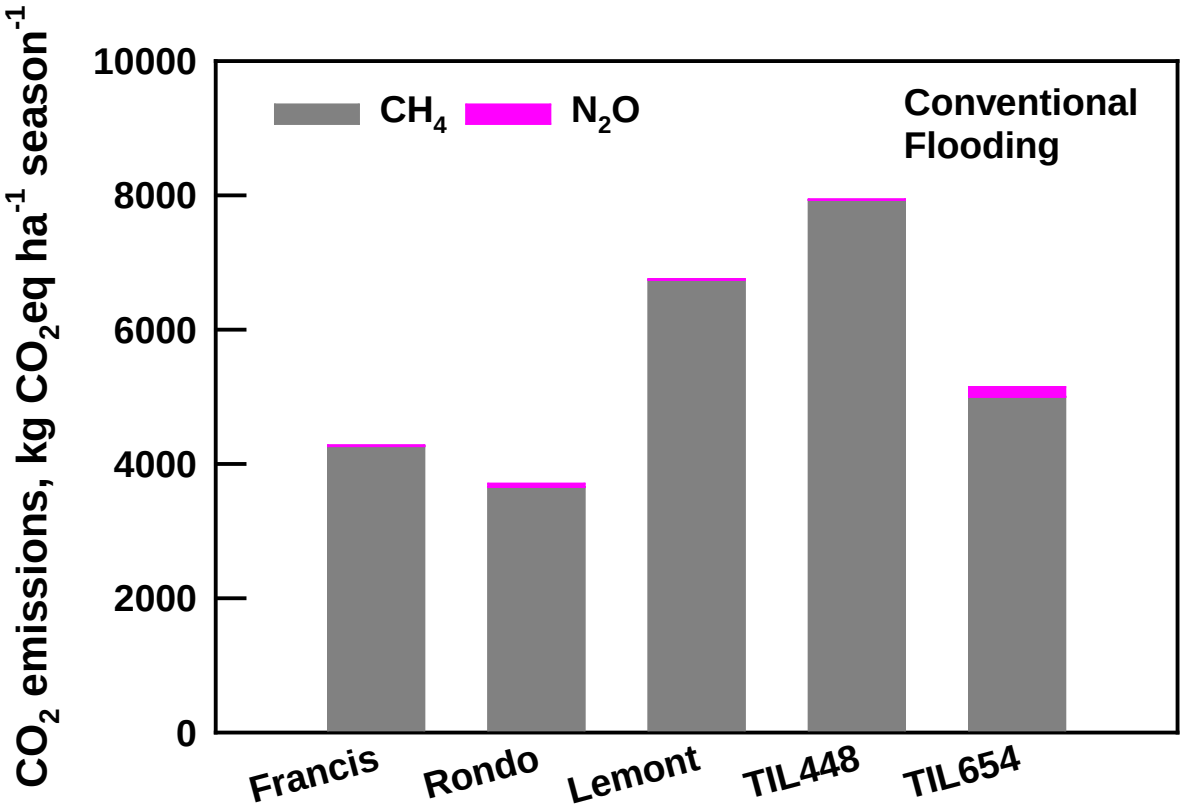
Field study 2: Furrow rice irrigation and hybrid rice in drill seeded system for reducing greenhouse gas emissions: First Year data

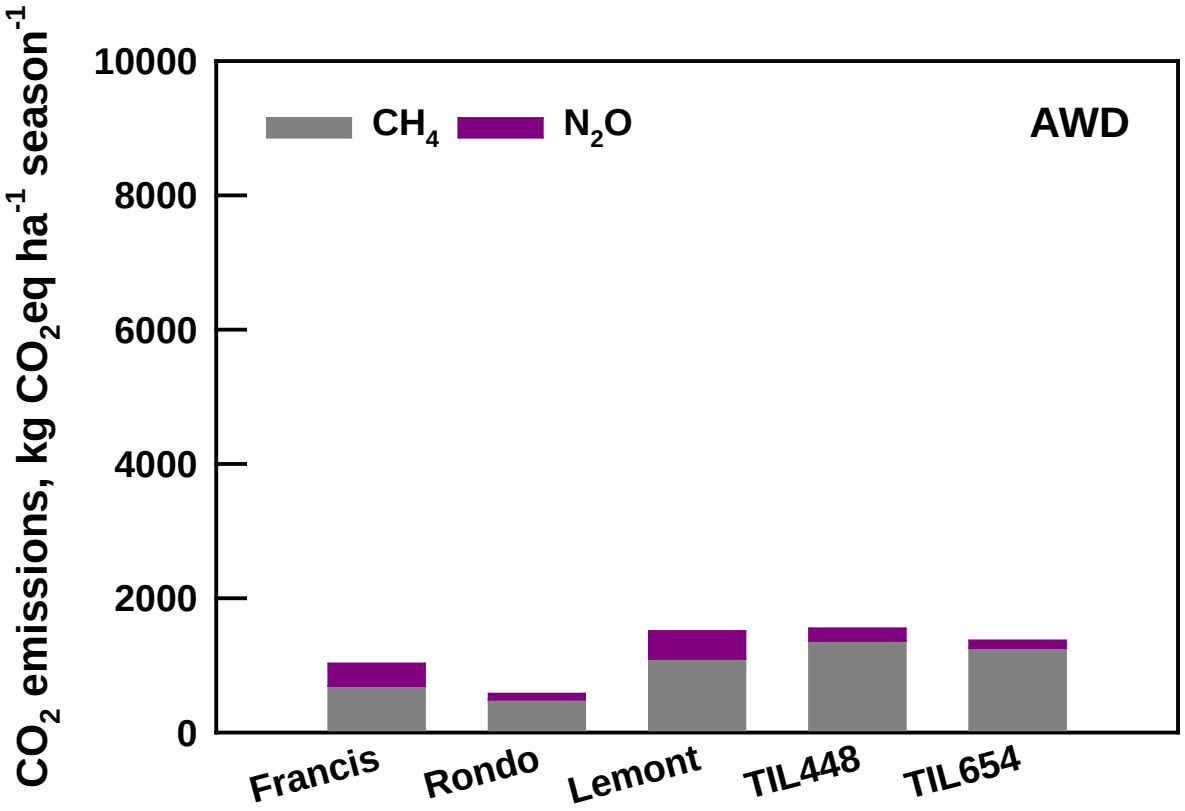




- ***Hybrid rice cultivars had 24% lower cumulative CH_4 emissions compared to inbred cultivar under continuous flooding.***
- ***Under furrow irrigation, some hybrid cultivars (7521 and 7321-Yara) decreased total CH_4 emissions by 11%***

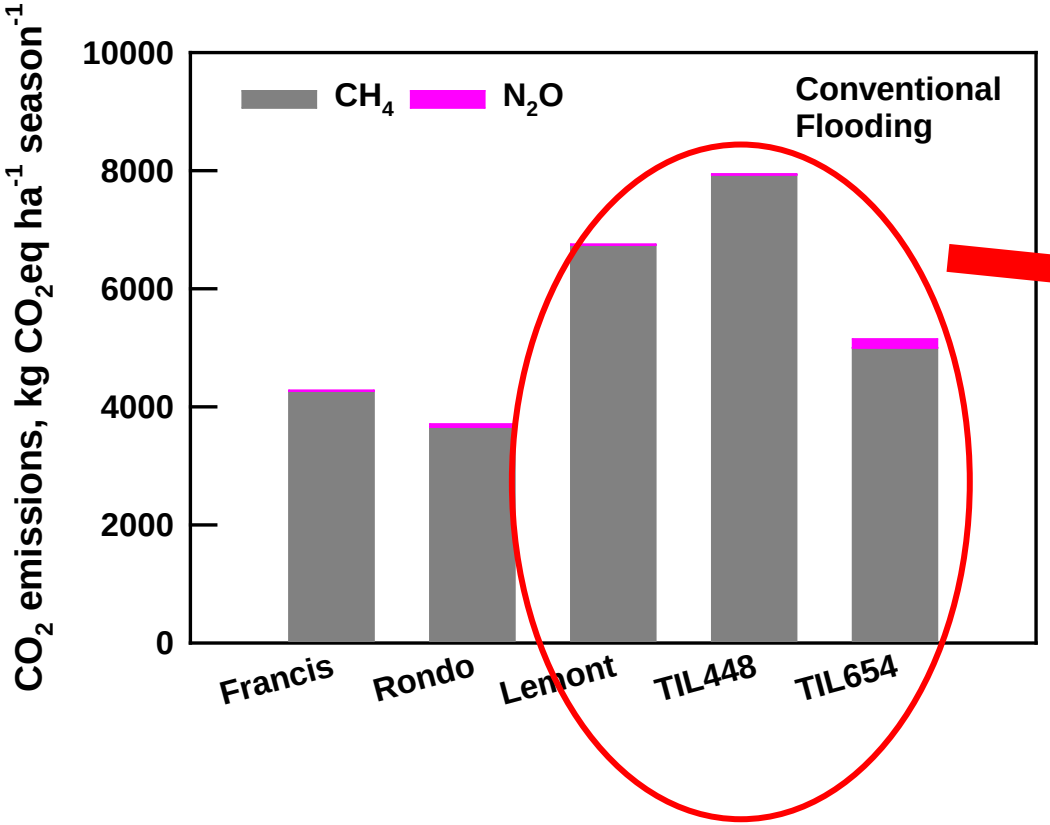
Field study 3: Understand the impacts of alternate wetting and drying irrigation on CH_4 and N_2O emissions and crop performance in selected rice cultivars

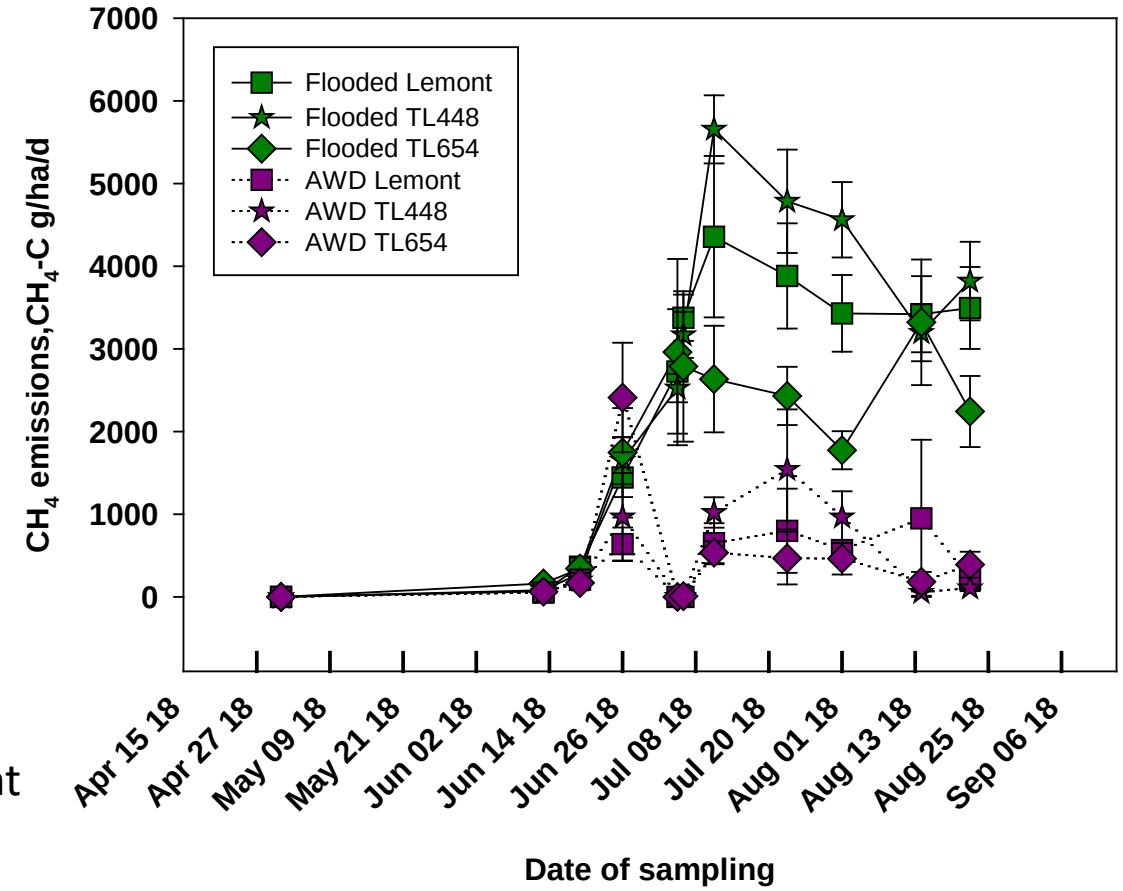




- ***AWD irrigation reduced CH_4 emissions by 82% but N_2O emissions increased by 28 times relative to conventional practice.***
- ***Rondo cultivar was the lowest emitting CH_4 among cultivars under both continuous flooding and AWD practice.***

Field study 3: Understand the impacts of alternate wetting and drying irrigation on CH_4 and N_2O emissions and crop performance in selected rice cultivars





Under continuous flooding practice:

TeQing-into-Lemont 448 emitted more CH_4 compared to Lemont

TeQing-into-Lemont 654 emitted less CH_4 compared to Lemont

Summary

- AWD management is an effective in reducing CH_4 emission compared to continuous flooding.
- Grain yields in all cultivars were not affected by AWD dry downs.
- CH_4 emissions were reduced by 56-82% following AWD practice.
- Hybrid cultivar CLXL745, RT7521 and RT7321-Yara further decreased CH_4 emissions under non-flooding practice i.e. AWD and Furrow irrigation.
- The use of some hybrid cultivars and high yielding inbreds has the potential to further decrease cumulative CH_4 emissions when combined with non-continuous flooding practice.
- N_2O emissions may offset reduction of CH_4 emissions when water and fertilizer applications are not managed effectively.

Thank you

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