Efficient Fertilizer and Water Management in Rice Cultivation for Food Security and Mitigating Greenhouse Gas Emissions

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Nitrogen Use Efficiency

- Less than 50% of the N applied is assimilated by plants
  - ✓ **Nitrogen recovery (RE_N): 30 – 50 %** (Broadcast)
- Losses to the environment

Losses mechanisms	Environmental Consequences
Nitrate leaching	Ground water contamination
Surface runoff and lateral seepage	Eutrophication (Algal bloom)
Ammonia volatilization, nitric oxide	Acid rain and ammonia deposition
Nitrous oxide emissions	**Global warming**
Nitrous oxide and nitric oxide emissions	**Stratospheric ozone depletion**

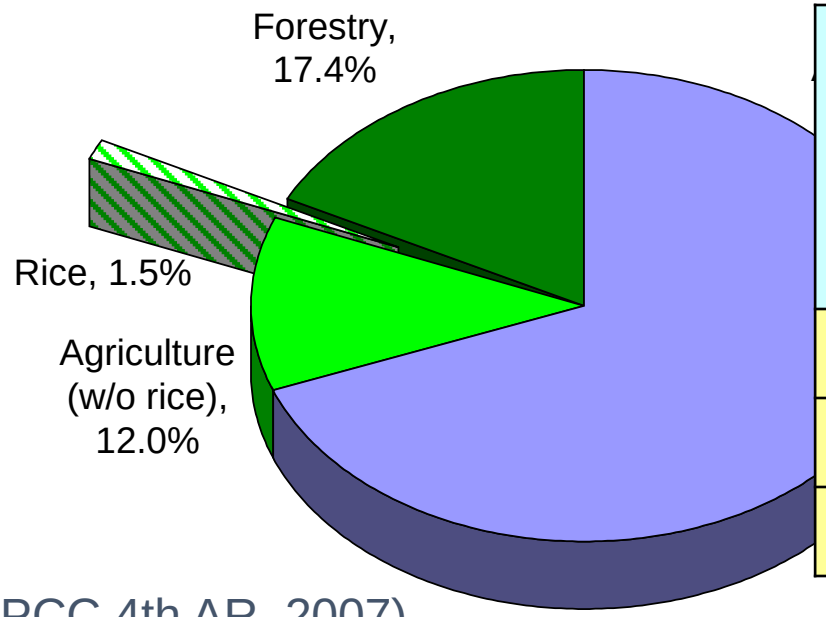
Agriculture in Bangladesh

- Rice occupies 80% of agricultural land (~11 m ha)
  - ✓Three seasons per year (Aus, Aman and Boro)

- Irrigated rice fields are the major source of greenhouse gases (GHGs), i.e., methane (CH_4) and nitrous oxide (N_2O)

- Global warming potential (GWP)
  - ✓CH_4: 25 CO_2 eq.
  - ✓N_2O: 298 CO_2 eq.

Significance of Rice Fields for GHG budgets



(IPCC 4th AR, 2007)

Country	National Scale in Asia: Emissions from rice production	
	(Gg CO2eq)	Perc. of total
Bangladesh	7,996	7.2 %
India	74,360	5.7 %
Myanmar	10,651	14.3 %

Data from the most recent National Communication submitted to UNFCCC

- Urea consumption in 2011 was 2.83 million tons
  - 7.92 million tons of CO_2-equivalent emission
- There is no measured data for both methane and nitrous oxide emissions
  - Measurement is the first step of mitigation

Climate smart fertilizer management

- Increase productivity and farm profit
- Improves soil fertility and soil health
- Mitigate GHGs emissions

Best Management Practices (BMPs)- 4Rs

- ✓ **Right source**
- ✓ **Right quantity**
- ✓ **Right time and**
- ✓ **Right placement**

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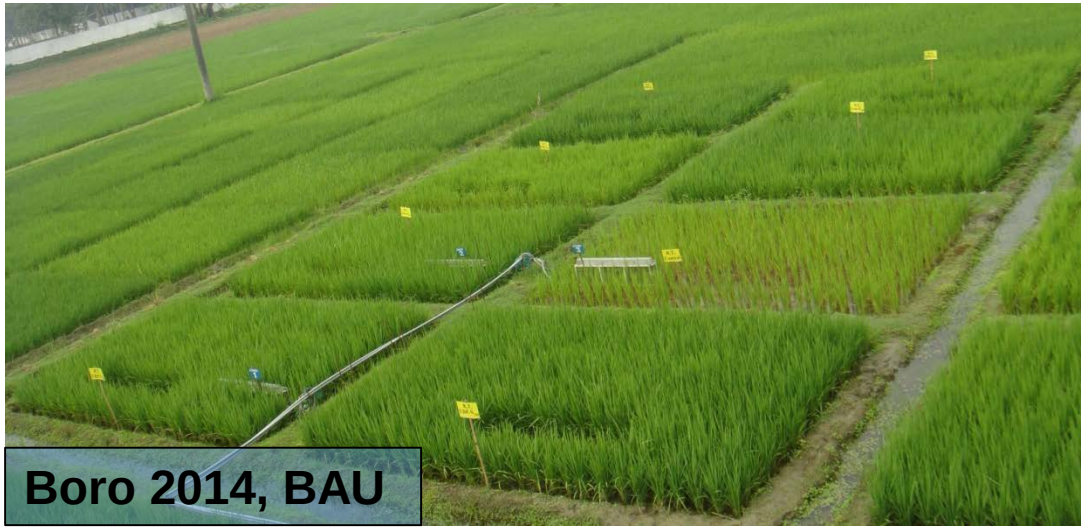
Urea deep placement (UDP): multiple benefits

- Increase grain yields by up to 20% while saving 30% urea fertilizer
- Reduces N losses and increase nitrogen recovery from 35-45 % to 70-75%
- Increase farm income
- Saves government subsidy



Rice Cultivation and Soil Fertility

- Most studies with UDP conducted under continuous flooded irrigation
- Irrigated rice cultivation is a sustainable way of farming
  - ✓maintain and improve soil fertility
- However, with increasing water scarcity, irrigation regime has changed from continuous flooding to alternate wetting and drying (AWD)
- Change in irrigation regime may affect fertilizer use efficiency

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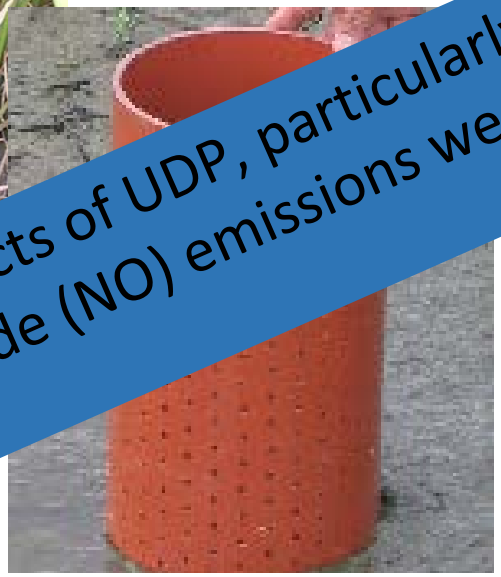
Alternate wetting and drying (AWD)

- Irrigate when water is 15 cm below soil surface
- Keep 5-cm floodwater at 10 DAT and at flowering
- Message for farmers: ‘Water is there even when you can’t see it’



Environmental impacts of UDP, particularly on nitrous oxide (N_2O) and nitric oxide (NO) emissions were not quantified

- S… …s
- …yield: No yield …nalty
- Increase water productivity
- Increase profit in deep well and shallow tube well systems

➢ **About 43% reduction in methane emissions (Sander, Wassmann et al. 2014)**

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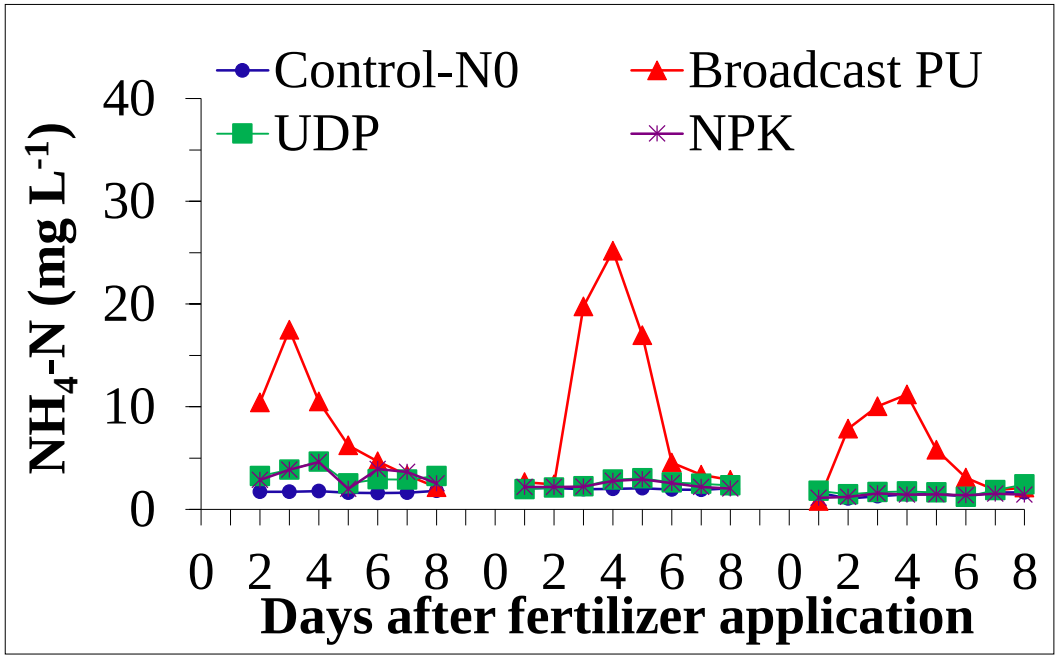
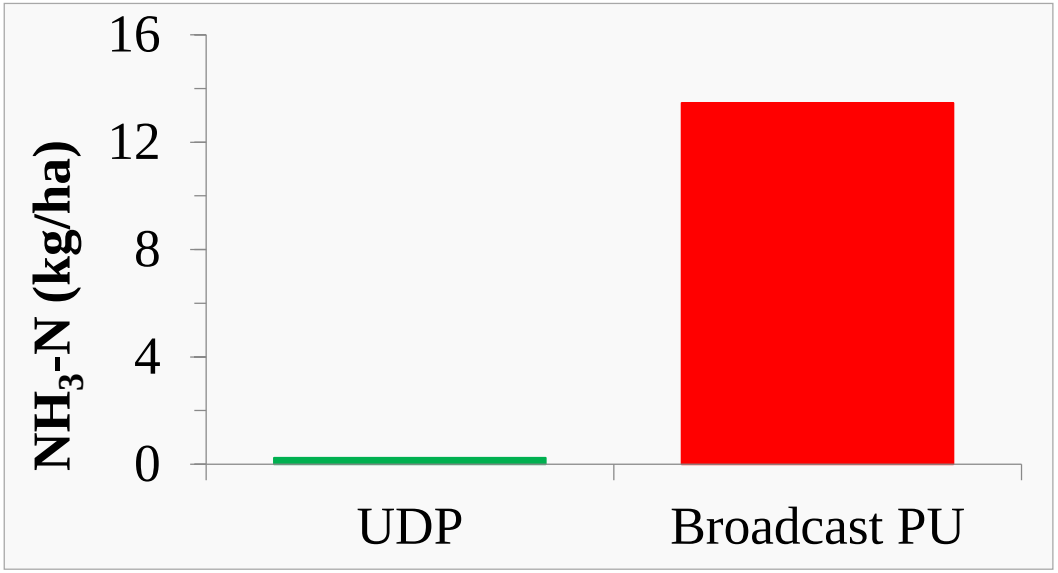
Measurements of GHG (N_2O and NO) Emissions

- Two laboratory equipped with automated GHG emissions measurement facilities
  - ✓ Bangladesh Agricultural University (BAU)
  - ✓ Bangladesh Rice Research Institute (BRRI)
- **Measurements:** continuous for 24 hours a day, seven days a week throughout rice growing and fallow seasons (14 seasons)
  - ✓ Nitrous oxide
  - ✓ Nitric oxide

UDP reduces N losses





- Deep placement of urea or NPK briquette drastically reduced ammonium in floodwater
- This in turn reduces ammonia volatilization

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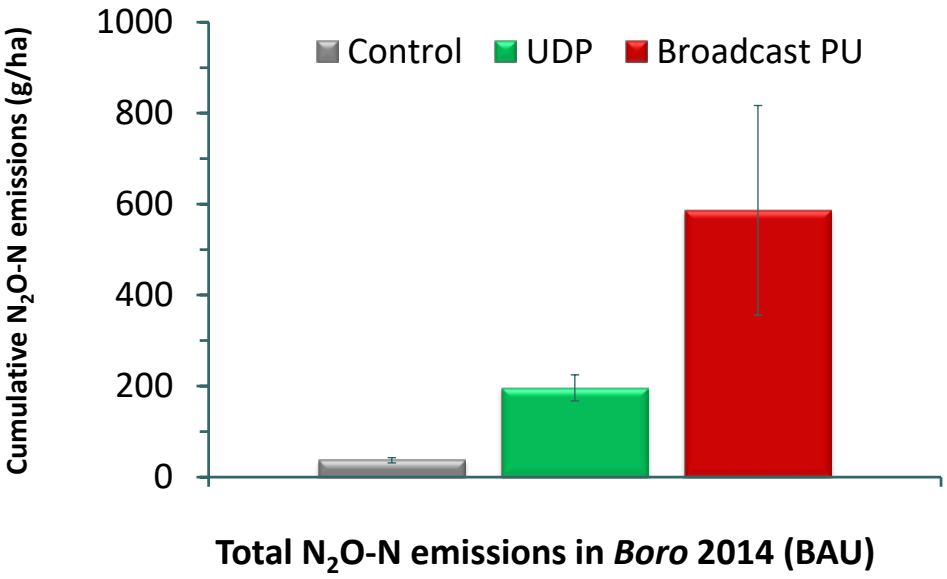
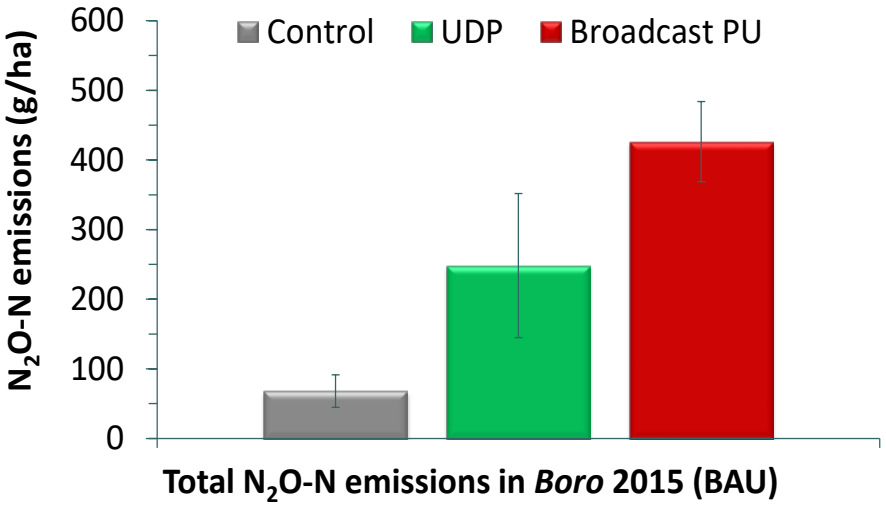
UDP reduces GHG nitrous oxide emissions

Continuous flooding irrigation



AWD Irrigation



Reduced N_2O: ~ 400 g ha^{-1} = ~187 kg CO_2 equivalent

4m ha Boro rice = 748, 000 mt CO_2 equivalent

Carbon credit: ~ 6 m USD (1 mt CO_2 = USD 8)

1 g N_2O-N = 1.57 g N_2O, 1 g N_2O = 298 g CO_2 equivalent

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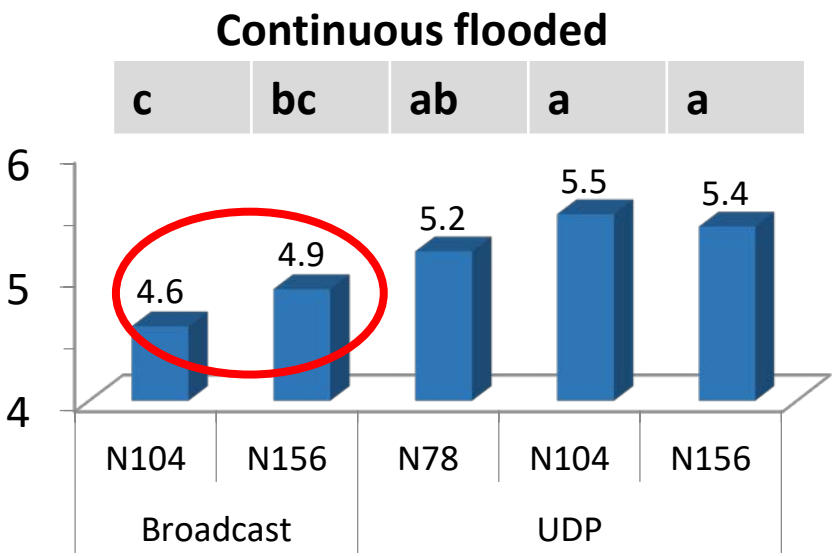
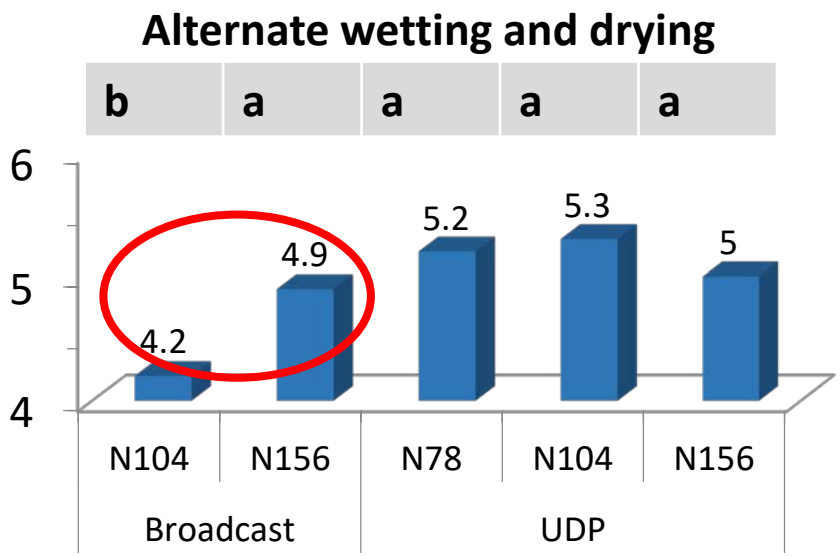
UDP increased grain yields and NUE





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ORIGINAL ARTICLE

Floodwater ammonium, nitrogen use efficiency and rice yields with fertilizer deep placement and alternate wetting and drying under triple rice cropping systems

Azmul Huda · Yam Kanta Gaihre · M. R. Islam · Upendra Singh · Md. R. Islam · Joaquin Sanabria · M. Abdus Satter · Hasina Afroz · Alee Halder · M. Jahiruddin

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UDP reduces GHG nitrous oxide emissions

- **UDP under AWD irrigation was as efficient as under continuous flooding irrigation**
  - ✓ **Reduced losses including GHG nitrous oxide emissions**
  - ✓ **Increase nitrogen use efficiency**
  - ✓ **Increased grain yields**

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Impacts of urea deep placement on nitrous oxide and nitric oxide emissions from rice fields in Bangladesh

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Scaling out: Prospects and challenges

- Entrepreneurship development and income generation: small scale farming with household labor

BUT

- Large scale farming: availability of briquette and labor for deep placement

- Industrial production of briquette

- Efficient mechanized on-farms deep placement solutions (PPP)

Acknowledgements

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