Accelerating Agriculture Productivity Improvement (AAPI)

Integrating Greenhouse Gas (GHG) Emissions Mitigation into the Feed the Future Bangladesh Fertilizer Deep Placement Rice Intensification (GHG) Project

Quarterly Report

(April-June 2013)

Submitted to

USAID/Bangladesh
Cooperative Agreement Number AID-388-A-10-00002

by

IFDC
P.O. Box 2040
Muscle Shoals, Alabama 35662, USA

www.ifdc.org

July 2013

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Acronyms

AAPI	Accelerating Agriculture Productivity Improvement
AWD	Alternate Wetting and Drying
BAU	Bangladesh Agricultural University
BRRI	Bangladesh Rice Research Institute
C	Carbon
CDCS	Country Development Cooperation Strategy
cm	centimeter
CSO	Chief Scientific Officer
CSW	Continuously Standing Water
DAT	Days after transplanting
FDP	Fertilizer Deep Placement
FTF	Feed the Future
g	gram
GCC	Global Climate Change
GCCI	Global Climate Change Initiative
GHG	Greenhouse Gas
ha	hectare
IFDC	International Fertilizer Development Center
IRRI	International Rice Research Institute
K	Potassium
kg	kilogram
KVA	kilovolt-ampere
m	meter
meq	milli-equivalence
MOP	Muriate of Potash
N	Elemental Nitrogen
N_2	Nitrogen Gas
N_2O	Nitrous Oxide
NH_4	Ammonium
NH_4-N	Ammonium Nitrogen

NO	Nitric Oxide
NPK	Nitrogen, Phosphorus and Potassium
P	Phosphorus
PDB	Power Development Board
PI	Panicle initiation
ppm	parts per million
PU	Prilled Urea
psig	pound-force per square inch
RCB	randomized complete block
S	Sulfur
t	ton
TSP	Triple Superphosphate
UDP	Urea Deep Placement
UPS	Uninterrupted Power Supply
USA	United States of America
USAID	United States Agency for International Development
Zn	Zinc

Accelerating Agriculture Productivity Improvement (AAPI)

Integrating Greenhouse Gas (GHG) Emissions Mitigation into the Feed the Future Bangladesh Fertilizer Deep Placement Rice Intensification (GHG) Project

Quarterly Report
(April-June 2013)

USAID/Bangladesh

Cooperative Agreement Number AID-388-A-10-00002

Introduction

In October 2011, the United States Agency for International Development (USAID)/Bangladesh submitted a proposal for a Global Climate Change (GCC) integration pilot project. This project targeted the integration of two Presidential Initiatives: the Feed the Future (FTF) Initiative and the Global Climate Change Initiative (GCCI). It also reflected the integration of two development objectives in the Bangladesh Country Development Cooperation Strategy (CDCS) 2011-16.[1]

The activities of the proposed concept note allow for the quantification of environmental impacts, particularly nitrous oxide (N_2O) and nitric oxide (NO) emissions reduction through fertilizer deep placement (FDP) technology, provide opportunities for carbon (C) credit payments and strengthen the capacity of the Bangladesh national research institutes. The activity was embedded within the Accelerating Agriculture Productivity Improvement (AAPI) project being implemented by International Fertilizer Development Center (IFDC) within the FTF portfolio and intended to enhance and extend the impact of the AAPI project. The proposal was accepted in February 2012. This led to an AAPI contract addendum signed on September 25, 2012.

[1] Development Objective 2: Food Security Improved; and Development Objective 4: Responsiveness to Climate Change Improved.

This progress report is part of the AAPI 11th quarterly report and is intended to brief stakeholders on the progress of the Integrating Greenhouse Gas (GHG) Emissions Mitigation into the Feed the Future Bangladesh Fertilizer Deep Placement Rice Intensification Project (GHG Project) in the third quarter (April-June 2013) of its implementation.

Project Description

The GHG Project measures GHG fluxes and other nitrogen losses associated with urea fertilizer applied to rice crops at two sites:

1. The Bangladesh Agricultural University (BAU) at Mymensingh.
2. The Bangladesh Rice Research Institute (BRRI) at Gazipur.

Working within these institutions will enhance their capacity, enabling them to achieve excellence in research that addresses climate change issues and improves understanding of the dynamics that impact climate change.

The project is designed in two phases:

- Phase I: Quantification of N losses and capacity building.
- Phase II: Effect of enhanced efficiency technologies on N emissions and yield.

The Project Timeframe

The Program Description Addendum proposes a timeframe over six seasons, starting with *Boro* 2012-2013 (see Table 1).

Table 1. Timeline and Milestones

Project	Integrating GHG Emissions Mitigation into the Feed the Future Bangladesh Fertilizer Deep Placement Rice Intensification Project
Objective	To quantify N losses using standardized procedures and capacity building on the measurement of GHG fluxes and mitigation of these fluxes with enhanced efficiency nutrient and water technologies

Phase I: Capacity Building on the Quantification of N Losses												
	Boro-1				*Aus*-1				*T. Aman*-1			
• Procurement, calibration and shipment	■	■										
• Setup and installation at relevant institutes with scientists			■	■								
• Initial soil characterization			■	■								
• Establishment of field trial with GHG monitoring				■	■	■	■	■	■	■	■	■
• N fluxes measurement from chambers				■	■	■	■	■	■	■	■	■
• Soil and air temperature and soil moisture data				■	■	■	■	■	■	■	■	■
• Runoff and leaching data				■	■			■		■	■	
• Operating manual for GHG measurement		■	■	■	■	■	■	■	■	■	■	■
• Training of Bangladeshi scientists for GHG measurement			■	■	■	■	■	■	■	■	■	■
Phase II: Effect of Enhanced Efficiency Technologies on N Emissions and Yield												
	Boro-2				*Aus*-2				*T. Aman*-2			
• Establishment of water regime x FDP trials	■	■	■	■	■	■	■	■				
• Comparison of N emissions: urea vs. FDP	■	■	■	■	■	■	■	■	■	■	■	■
• Comparison of N emissions: flooded vs. reduced water use	■	■	■	■	■	■	■	■	■	■	■	■
• Comparison of N emissions: rice vs. fallow vs. non-rice	■	■	■	■	■	■	■	■	■	■	■	■
• Quantification of runoff and leaching loss in above systems	■	■	■	■	■	■	■	■	■	■	■	■
• Quantification of volatilization loss in above systems	■	■	■	■	■	■	■	■	■	■	■	■
• Assessment of impact of FDP on yield and N emission				■				■				■
• Assessment of impact of drying on yield and N emission				■				■				■
• Highly qualified and trained staff for GHG measurement	■	■	■	■	■	■	■	■	■	■	■	■

Source: Attachment 2 – Program Description Addendum. Modification No. 3.

Progress Against the Timeframe

The project signed the project addendum during September 2012. The *Boro* crop was planted during the last week of January (BAU) and the first week of February (BRRI), 2013.

Table 2. Progress Against Timeline

Phase I: Capacity Building on the Quantification of N Losses												
	Boro-1						*Aus*-1			*T. Aman*-1		
	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013	Jul 2013	Aug 2013	Sep 2013	Oct 2013	Nov 2013
• Procurement, calibration and shipment					Complete							
• Setup and installation at relevant institutes with scientists							Complete					
• Initial soil characterization	Completed in 2012											
• Establishment of field trial with GHG monitoring						*Boro*		*Aus*				
• N fluxes measurement from chambers												
• Collection of soil and air temperature and soil moisture data												
• Collection of runoff and leaching data (collection and analysis of water samples for NH_4)				Complete				Aus		*Aman*		
• Development of operating manual for GHG measurement												
• Training of Bangladeshi scientists for GHG measurement					USA		within Bangladesh					
Phase II: Effect of Enhanced Efficiency Technologies on N Emissions and Yield												
	Boro-2				*Aus*-2				*T. Aman*-2			
	Dec 2013	Jan 2014	Feb 2014	Mar 2014	Apr 2014	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014
• Establishment of water regime x FDP trials												
• Comparison of N emissions: urea vs. FDP												
• Comparison of N emissions: flooded vs. reduced water use												
• Comparison of N emissions: rice vs. fallow vs. non-rice												
• Quantification of runoff and leaching loss in above systems												
• Quantification of volatilization loss in above systems												
• Assessment of impact of FDP on yield and N emission												
• Assessment of impact of drying on yield and N emission												
• Highly qualified and trained staff for GHG measurement												

— Activity completion → Expected completion

Table 2 shows progress against the timeline. All activities began on time but have stretched beyond their timelines. Phase I has many components that are interdependent and need to be synchronized to obtain measurements in the field.

Phase I: Capacity Building on the Quantification of N Losses

Only Phase I will be reported herein. Phase II is scheduled for the second year, although much of the data required in Phase II will be collected in Phase I.

Fixed Obligation Grants with BAU and BRRI

An agreement for a fixed obligation grant was signed with the Department of Soil Science, BAU and Soil Science Division, BRRI effective November 1, 2012, with an anticipated completion date of August 31, 2014. The amount of $45,271 is a fixed contribution to be used by each institution to carry out field trials, gas measurements and laboratory analysis according to protocols provided by AAPI. It requires that institutions appoint junior scientists full-time for the full term of the project (22 months). The junior scientists will be responsible for the day-to-day implementation of the project. AAPI will provide one month's training for the junior scientists (one from each institution) on the operation and maintenance of the equipment. This training is to be held at IFDC headquarters, Alabama, United States of America (USA).

BAU appointed Mr. Azmul Huda on November 5, 2012. He has also enrolled as a Ph.D. student and will incorporate aspects of the project within his thesis. BRRI appointed Mr. S.M. Mofizul Islam on November 5, 2012. Both institutions have nominated senior staff to oversee the project and serve as contact points. Both scientists received one month's training on the operation and maintenance of the equipment at IFDC headquarters, Alabama, USA during the period of April 6 to May 6, 2013.

Appointment of AAPI Staff

The position of resident expert – post doc was appointed on April 22 and the position of local environment specialist was appointed on April 7, 2013.

All short-term experts will be sourced from within IFDC.

Procurement, Calibration and Shipment

The system to measure NO and N_2O was custom-built at IFDC headquarters, Alabama, USA. Initial calibration of both NO and N_2O analyzers was done in Alabama. All the equipment, along with related parts, was received by IFDC, Dhaka at the end of April 2013.

Twelve gas chambers were placed within designated experimental plots (further detail within sub-section "Installation of Equipment"). The system control box and gas analyzers were installed in the field laboratories. The system works on a three-hour cycle, i.e., one hour for each replication. It is controlled and data are collected by a Campbell Scientific CR3000 Data Logger with an AM16/32 Channel Relay Multiplexer (for temperature and soil water potential sensors) and two 16 Channel AC/DC Relay Controllers (for sampling valves and air control valves). NO is measured with a Teledyne API T200 Chemiluminescence Analyzer. N_2O is measured with a Teledyne T320U Gas Filter Correlation Analyzer, and calibration gases are made with a Teledyne T700 Dynamic Dilution Calibrator. The equipment includes a Dell Latitude 6330 notebook PC. All were procured and assembled by staff at IFDC headquarters, Alabama, USA before shipping to Bangladesh.

Each site requires calibration gases (N_2, NO and N_2O) of high purity. The gases were procured locally from Linde Bangladesh Limited through a special order. The gas cylinders were received at the sites (BRRI and BAU) on May 12, 2013. A total of 15 gas cylinders, nine for N_2 and three each for NO and N_2O, were procured, of which four cylinders for N_2 and one each for NO and N_2O were placed at BRRI, Gazipur and five cylinders for N_2 and two each for NO and N_2O were placed at BAU, Mymensingh. Regulators for gas cylinders, valves and spare parts were been procured from Linde.

Two air compressors having maximum pressure of 120 pound-force per square inch (psig) and with a storage tank of 120 liters were procured locally during May 2013 and fitted with regulators (received from IFDC headquarters) to set the output pressure of 70 psig. The two air compressors were installed at the two sites. The compressors were fitted with a 1.5 HP motor having the frequency of 50 cycles/sec, rpm of 1400 and power requirement of 220 volts.

Setup and Installation at Relevant Institutes with Scientists

Both BAU and BRRI allocated land to accommodate the field trials and the establishment of field laboratories to house the equipment. Construction of laboratory buildings was completed at both locations during April 2013. Field trials have been conducted at both locations since inception of the project. The junior scientists at both sites are responsible for day-to-day activities of the project. Dr. Md. Abdul Latif Shah, chief scientific officer (CSO) and Head, Soil Science Division, BRRI, is the principal investigator for the BRRI component; and Professor Dr. Md. Rafiqul Islam (Senior) is working as the principal investigator and Professor Dr. Md. Rafiqul Islam (Junior) is working as the co-principal investigator of the project for the BAU component.

Field Laboratories

Construction of the lab building began on December 23, 2012, at BRRI and December 24, 2012, at BAU. Construction was completed and handed over during April 2013 after final inspection by the AAPI engineer along with the BAU and BRRI engineers at their respective sites. The BAU site required an electrical transformer and water supply. The transformer was procured by AAPI and installed by the Power Development Board (PDB). A tube well was drilled and the water connected. BRRI has both power and water on-site.

A backup generator and uninterrupted power supply (UPS) are required at both sites to ensure continuous power supply to the machines. A high power automatic generator (10 kilovolt-amperes [KVA]) was installed at both sites. An online UPS (2 KVA) was installed at both BRRI and BAU during May 2013. Both generators and UPS are now working well.

Installation of Equipment

The Principal Scientist from IFDC headquarters, USA and Local Environment Specialist, Post-Doctoral Scientist and Junior Scientists at BAU and BRRI worked for about one month (May 15-June 15, 2013) to install the equipment at each site. Installation was done between harvest of *Boro* rice and transplanting of *Aus* rice.

Twelve gas chambers were placed in each location. Gas chambers were placed in experimental plots of three treatments (T1, T2 and T7 – see Table 4). Nine gas chambers are used for continuously flooded fields (three replicates for each treatment), while three chambers were used for alternate wetting and drying (AWD) fields for the same treatments but without replication. Each chamber was connected with Teflon tubes for gas sampling, nylon tubes (with compressed air) for opening and closing of chambers, temperature and moisture sensors and electric wire for a fan that is used inside the chamber to mix air uniformly. All the tubes and wires were passed through 0.75″-diameter PVC pipes for better management and to protect them from unwanted damage in the field. All the tubes, sensors and wires were connected to a control box inside the laboratory. The sampling tubes inside the laboratory room were wrapped with insulating materials to prevent condensation of moisture due to cold temperature in the air-conditioned lab. The control box, data logger and gas analyzers were all interconnected as per design.

The calibration gas cylinders (N_2, NO and N_2O) were also installed in the laboratories (kept upright and fixed to the wall with clamps) and connected to the specified machines for routine calibration of gas analyzers.

An air compressor was installed in the generator room of each lab, and the outlet was connected to the control box and then with gas chambers in the field using nylon tubes. Compressed air is required to open and close the chamber tops at specified times and is controlled by the software.

Installation of equipment and gas chambers was completed at BAU on June 3 and at BRRI on June 9. The laboratory of BAU was formally inaugurated on June 4, 2013, by Prof. Dr. Md. Abdul Khaleque Patwary, Dean, Faculty of Agriculture, BAU on behalf of the Vice Chancellor of the institution.

Initial Soil Characterization

Both institutions have completed soil analysis of their sites (BAU in January 2012 and BRRI in February 2012). Initial physicochemical properties of the soil are presented in Table 3.

Table 3. Physicochemical Properties of Soil at BAU and BRRI

Soil property	BAU		BRRI
	CSW	AWD	CSW and AWD
pH	5.37	5.44	6.22
Organic C (%)	1.76	1.28	1.75
Total N (%)	0.17	0.13	0.17
Available P (ppm)	2.88	3.04	16
Exchangeable K (meq/100g)	0.09	0.08	0.25
Available S (ppm)	12.66	11.07	-
Texture	Silt loam	Silt loam	Clay loam

CSW: continuous standing water, AWD: Alternate wetting and drying

Establishment of Field Trial with GHG Monitoring (*Boro* 2013)

Trial protocols were prepared by IFDC in collaboration with BAU and BRRI scientists. Two field experiments were conducted during the 2013 *Boro* season at each location. In each location, one experiment was conducted under CSW condition and the other under AWD condition. The objectives of the studies were to observe the effects of broadcasting prilled urea (PU), urea briquette deep placement and NPK briquette deep placement on ammonium nitrogen (NH_4-N) concentration in floodwater, rice yield and N uptake by rice. There were eight treatments (Table 4) in both the experiments. Treatments were arranged in a randomized complete block (RCB) design with three replications at BAU and six replications at BRRI. The unit plot size was 6 meter (m) x 4 m at BAU and 4.8 m x 3.2 m at BRRI. Modern rice variety, BRRI Dhan 28, was used as the test crop.

Table 4. Treatment Description for Greenhouse Gas Emission Trial during *Boro* Season 2013

Trt. No.	Description	N Rate	P Rate	K Rate	Basal/Deep-Placed N	1st Topdress N	2nd Topdress N
		Kg/ha					
Bangladesh Agricultural University (BAU)							
1	Check	0	25[a]	64[b]	0	0	0
2	Urea briquette (one 2.7 g)	78	25[a]	64[b]	78	0	0
3	Urea briquette (two 2.7 g)	156	25[a]	64[b]	78	0	0
4	Prilled urea	78	25[a]	64[b]	26	26	26
5	Prilled urea	156	25[a]	64[b]	52	52	52
6	NPK briquette (two 2.4 g)	78	16[c]	42[c]	78	0	0
7	Urea briquette (two 1.8 g)	104	25[a]	64[b]	104	0	0
8	NPK briquette (two 3.4 g)	102	25[d]	64[d]	102	0	0
Bangladesh Rice Research Institute (BRRI)							
1	Check	0	25[a]	64[b]	0	0	0
2	Urea briquette (one 2.7 g)	78	25[a]	64[b]	78	0	0
3	Urea briquette (two 1.8 g)	104	25[a]	64[b]	104	0	0
4	Prilled urea	78	25[a]	64[b]	26	26	26
5	Prilled urea	104	25[a]	64[b]	34	35	35
6	NPK briquette (two 2.4 g)	78	16[c]	42[c]	78	0	0
7	Prilled urea	156	25[a]	64[b]	52	52	52
8	NPK briquette (two 3.4 g)	102	25[d]	64[d]	102	0	0

a. Applied as triple superphosphate.
b. Applied as muriate of potash .
c. P and K is applied as NPK briquette (Treatment 6).
d. P and K is applied as NPK briquette (Treatment 8).

All the treatments except T6 and T8 received 25 kilograms (kg) P/ha and 64 kg K/ha from triple superphosphate (TSP) and muriate of potash (MOP), respectively. Sulfur and zinc were applied to all plots at the rate of 20 kg S/ha as gypsum and 3 kg Zn/ha as zinc oxide. Fifty-day-old rice seedlings were transplanted at BAU and forty-day-old rice seedlings at BRRI. Transplanting was done at the spacing of 20 cm x 20 cm in both the experiments at both locations. The seedlings were transplanted on January 31, 2013, at BAU and on February 10-11, 2013, at BRRI. Prilled urea was applied in three splits at 10, 34 and 55 days after transplanting (DAT) and mixed thoroughly with the soil immediately after application. Urea briquettes and NPK briquettes were applied at 10 days after transplanting (DAT). The briquettes were placed at a depth of 8-10 cm between four hills at the alternate rows. Before application of N fertilizer, water was drained from the fields.

In CSW plots, floodwater was maintained 6-9 cm to keep the plots under continuously standing water condition. Water depth was monitored. In AWD plots, 25 cm long perforated (up to 15 cm) PVC pipes of 10 cm diameter were inserted (perforated end) into the soil up to a depth of 15 cm leaving 10 cm above the ground. Soils inside the pipes were removed to make a hole of 15 cm depth. Water depth in the PVC pipes was kept under close observation and irrigation water was applied to a height of about 6-9 cm immediately when water inside the pipes became invisible. The AWD treatment started 15 DAT and continued until one week before flowering stage of the crop.

Water sampling was done thrice, the first one after basal application of PU and deep placement of urea briquettes and NPK briquettes, the second and third ones after topdressing of PU. In each sampling, the first sample was collected two hours after the application of fertilizers and the subsequent samplings were done for seven consecutive days. Samples were collected once a day (in the morning) in acid-washed plastic bottles and brought to the laboratory to measure pH and NH_4-N. Water temperature of the field was also monitored.

The crop was harvested from April 27 to May 5, 2013, at BAU and on May 29, 2013, at BRRI. The grain and straw yields were recorded. Two additional harvests were also done in each plot at the panicle initiation (PI) and heading stages at BAU; and at maximum tillering and heading stages at BRRI. A total of 30 hills (3 hills x 10 hills) were harvested at each stage and the biomass weight and N content were determined. The grain and straw samples were analyzed for total N concentration and the uptake of N by grain and straw was also calculated at BAU; but at BRRI the analysis has not yet been completed.

Results

Bangladesh Agricultural University

Ammonium N Concentration in Flood Water

The results on the NH_4-N concentration in floodwater samples in different fertilizer treatments are presented in Figure 1-Figure 3. The NH_4 concentration in floodwater of prilled urea treated plots (T4 and T5) varied widely at all sampling times but it did not vary much in other treatments. In all three samplings, the highest NH_4 concentration was observed in T4 and T5 on day 2 after application of PU and then decreased steadily with time. The NH_4 concentrations in the urea briquette treated plots (T2, T3 and T7) were very low at the first sampling while it was negligible during the second and third sampling. These results are in agreement with Jahan (2012)[2] who also found the maximum amount of ammonium N on day 2 after application of prilled urea in rice field water.

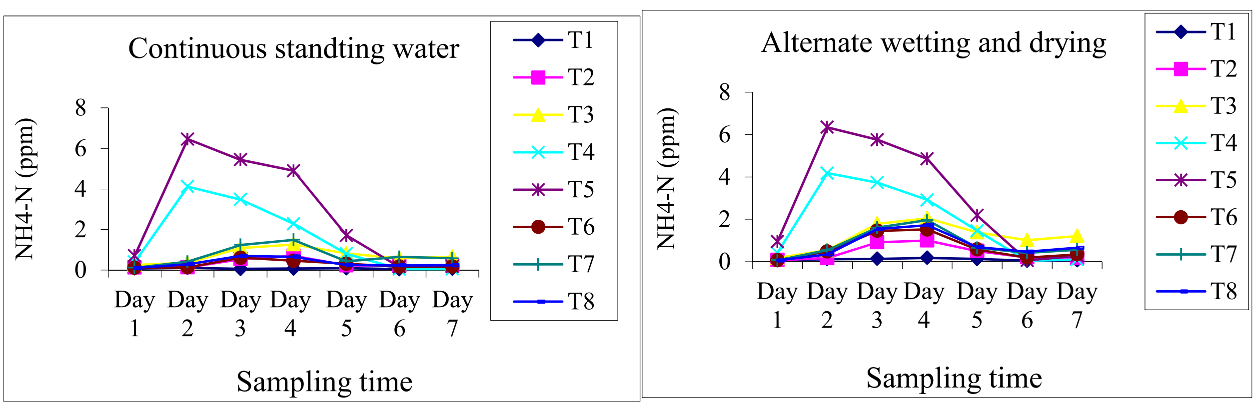


Figure 1. Changes in NH_4-N Concentration of Floodwater in CSW and AWD Conditions at Different Treatments During First Sampling (February 10-16, 2013)

---

[2] Jahan, N (2012). Effects of Prilled Urea, Urea Super Granules and Poultry Manure on Field Water Properties and Growth and Yield of Transplant *Aus* BR21. MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

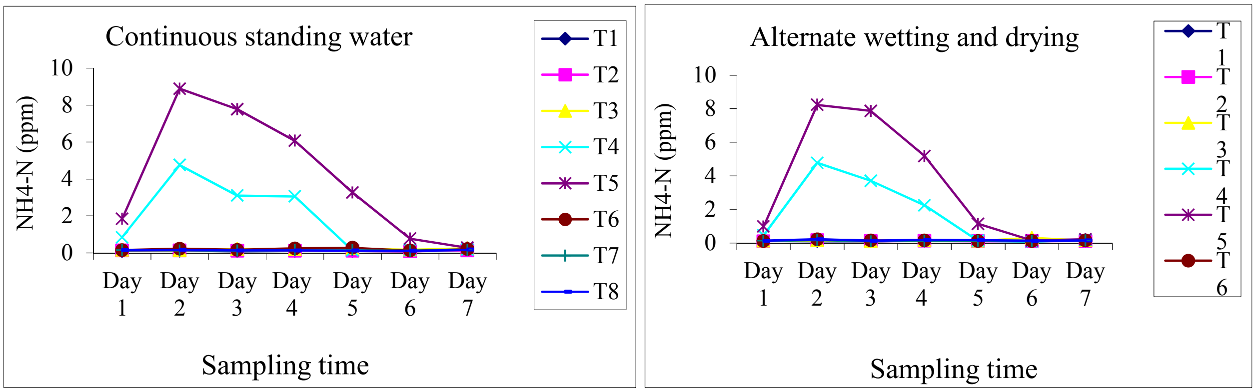


Figure 2. **Changes in NH_4-N Concentration of Floodwater in CSW and AWD Conditions at Different Treatments During Second Sampling (March 3-9, 2013)**

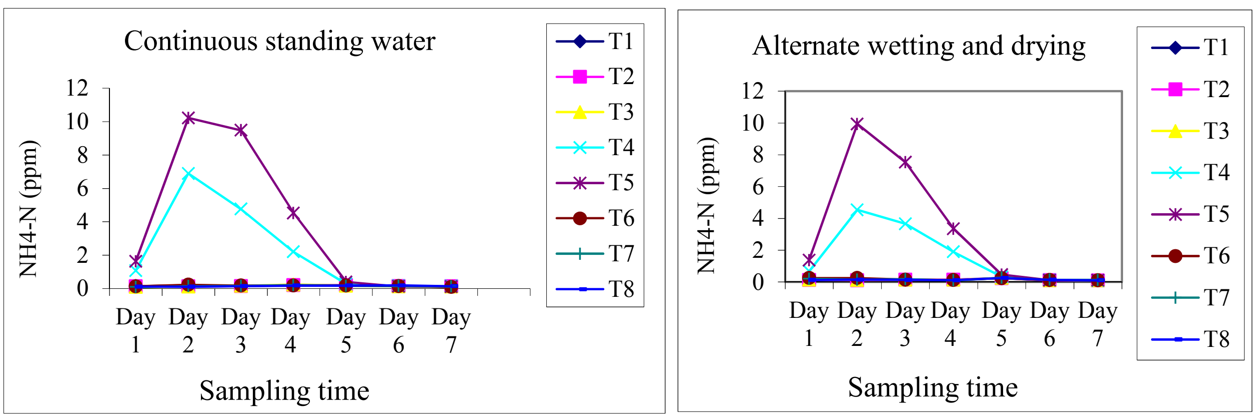


Figure 3. **Changes in NH_4-N Concentration of Floodwater in CSW and AWD Conditions at Different Treatments During Third Sampling (March 24-30, 2013)**

Biomass and Rice Yield

Biomass Weight at PI Stage

Biomass weight at PI stage ranged from 0.93 (T1) to 2.43 (T3) t/ha under CSW condition (Table 5) and 1.04 (T1) to 3.40 (T3) t/ha in AWD condition (Table 6). In both CSW and AWD conditions, T3 (urea briquette-N_{156}) had significantly higher biomass. However, biomass of T3 was statistically identical with T7 and T8 treatments under CSW condition.

Table 5. Effect of Prilled Urea, Urea Briquette and NPK Briquette on the Biomass Yield of BRRI Dhan 28 under CSW Condition

Trt. No.	Description	Biomass Weight PI	Biomass Weight Heading	Straw Yield	Grain Yield
		(t ha^{-1})			
T1	Check: N_0	0.93d	1.86d	1.95e	2.30d
T2	Urea briquette: N_{78} (one-2.7 g)	1.89bc	4.01b	4.50bc	5.40b
T3	Urea briquette: N_{156} (two-2.7 g)	2.43a	4.63a	6.22a	6.16a
T4	Prilled urea: N_{78}	1.19d	2.92c	2.96d	3.98c
T5	Prilled urea: N_{156}	1.69c	3.69b	4.33c	5.74ab
T6	NPK briquette: N_{78} (two-2.4 g)	1.89bc	3.82b	4.21c	5.26b
T7	Urea briquette: N_{104} (two-1.8 g)	2.17ab	4.85a	5.36ab	6.02a
T8	NPK briquette: N_{102} (two-3.4g)	2.12ab	4.05b	5.09bc	5.56ab
CV (%)		10.85	5.61	11.40	6.52

Within a column, numbers followed by the same letters are not significantly different by LSD at the 5% level of significance; CV (%) = Coefficient of variation.

Table 6. Effect of Prilled Urea, Urea Briquette and NPK Briquette on the Biomass Yield of BRRI Dhan 28 AWD Condition

Trt. No.	Description	Biomass Weight PI	Biomass Weight Heading	Straw Yield	Grain Yield
		(t ha^{-1})			
T1	Check: N_0	1.04f	1.75f	1.83d	2.42e
T2	Urea briquette: N_{78} (one-2.7 g)	2.89bc	4.83bc	5.43a	5.94ab
T3	Urea briquette: N_{156} (two-2.7 g)	3.40a	5.42a	4.18b	6.11a
T4	Prilled urea: N_{78}	1.80e	3.31e	3.06c	4.16d
T5	Prilled urea: N_{156}	2.28d	4.51cd	4.13b	5.35bc
T6	NPK briquette: N_{78} (two-2.4 g)	2.29d	4.19d	5.03ab	5.21c
T7	Urea briquette: N_{104} (two-1.8 g)	3.03b	5.16ab	5.53a	5.97ab
T8	NPK briquette: N_{102} (two-3.4g)	2.66c	5.01ab	4.78ab	5.52abc
CV (%)		7.72	5.61	13.18	7.43

Within a column, numbers followed by the same letters are not significantly different by LSD at the 5% level of significance; CV (%) = Coefficient of variation

Biomass Weight at Heading Stage

Biomass at heading stage ranged from 1.86 t/ha in T1 treatment to 4.85 t/ha in T7 treatment under CSW condition (Table 5), and from 1.75 t/ha (T1) to 5.42 t/ha (T3) under AWD conditions (Table 6). The highest yield was observed in T7 (NPK briquettes) under CSW and T3 under AWD condition. Under CSW, T7 was statistically similar with T3; while under AWD T3 was similar with T7 and T8.

Straw and Rice Grain Yield

Both straw and grain yield were the highest in T3 under CSW condition. However, T7 also had statistically similar yield with T3. On the other hand, the highest straw yield was observed in T7 under AWD condition. However, this yield was statistically similar with T2, T6 and T8. Unlike straw yield, the highest grain yield was observed in T3, and this was comparable with T2, T7 and T8.

Under CSW condition, treatment T3 [Urea briquette- N_{156}] produced the highest biomass at PI and heading stages and both straw and grain yield which was followed by T7 [Urea briquette- N_{104}] and T8 [NPK briquette- N_{102}]. Similarly, as in CSW, biomass at PI and heading stage and grain yield was higher in T3 but straw yield was higher in T7 under AWD condition.

Based on grain yield results the *Boro* recommendation for urea briquette application may be increased from a single 2.7 g (78 kg N/ha) to two 1.8-g urea briquettes (104 kg N/ha) or two 2.7-g urea briquettes (156 kg N/ha).

Nitrogen Uptake and N Recovery

N Uptake at Panicle Initiation Stage

The N uptake by shoot at PI stage of the rice grown under CSW ranged from 17.43 kg/ha in T1 treatment to 67.31 kg/ha in T3 treatment (Table 7). The highest N uptake was found in T3; however, it was statistically identical with treatments T7 and T8. Among the N treatments, T4 had the lowest N uptake. As in CSW condition, T3 had highest N uptake by shoot (92.02 kg/ha) under AWD condition and this was followed by T2, T7 and T8 (Table 8).

N Uptake at Heading Stage

N uptake by rice plant at heading stage under all fertilizer treatments for CSW and AWD conditions is shown in Table 8, respectively. The N uptake by shoot at heading stage of the rice grown under CSW ranged from 21.27 kg/ha in T1 to 78.61 kg/ha in T3. Similar to PI stage, the highest N uptake was found in T3 followed by T7 and T8. Under reduced irrigated condition, N uptake by shoot ranged from 21.09 kg/ha in T1 treatment to 97.88 kg/ha in T3 treatment. T3 had significantly higher N uptake than all other treatments under AWD condition (Table 8).

N Uptake at Harvest

N uptake by rice straw and grain at harvest in different fertilizer treatment under both CSW and AWD conditions is shown in Table 7 and Table 8. Under CSW condition, highest N uptake by both straw (40.45 kg/ha) and grain (76.3 kg/ha) was observed in T3 followed by T7 and T8. As in CSW, T3 had highest N uptake by both straw (29.23 kg/ha) and grain (95.89 kg/ha) under AWD condition.

Total N uptake by grain and straw of the rice grown under CSW condition ranged from 35.30 kg/ha in T1 treatment to 116.7 kg/ha in T3 treatment. The highest total N uptake was found in T3. However, it was statistically identical to T7 and T8 treatments. Similarly, the total N uptake by rice crop under AWD condition ranged from 33.36 kg/ha in T1 to 125.1 kg/ha in T3. Total N uptake in T3 was significantly higher which was followed by T7.

Nitrogen Recovery

Deep placement of urea briquettes and NPK briquettes showed higher N recovery percentage compared to surface application of PU under both water management practices (Table 7 and Table 8). Nitrogen recovery from urea briquettes decreased with an increase in N rates. Apparently N recovery from urea briquettes was higher under AWD condition compared with CSW condition. The highest N recovery of 79.8 percent was found when 78 kg N/ha was applied as urea briquettes under AWD condition. The N recoveries from NPK briquettes were 69.8 and 68.7 percent under CSW condition while 67.2 and 60.3 percent for AWD condition. Nitrogen recoveries from prilled urea under CSW condition were 37.7 and 40.7 percent while for reduced irrigated condition it was 38.7 and 38.6 percent. Based on the above results, the *Boro* recommended rate of a single 2.7-g urea briquette (T3) gave the highest N recovery under both CSW and AWD conditions.

Table 7. Effect of Prilled Urea, Urea Briquettes and NPK Briquettes on the Uptake and Recovery of N by BRRI Dhan 28 under CSW Condition

Trt. No.	Description	N Uptake		N Uptake at Harvest			% N Recovery
		PI	Heading	Grain	Straw	Total	
		(kg/ha)		(kg/ha)			
T1	Check: N_0	17.43e	21.27f	26.19d	9.120e	35.30d	-
T2	Urea briquette: N_{78} (one-2.7 g)	50.76bc	56.87d	67.01ab	23.91cd	90.92b	71.3
T3	Urea briquette: N_{156} (two-2.7 g)	67.31a	78.61a	76.30a	40.45a	116.7a	52.2
T4	Prilled urea: N_{78}	27.87d	38.26e	46.41c	18.27de	64.67c	37.7
T5	Prilled urea: N_{156}	45.62c	69.45bc	71.61ab	27.23bcd	98.84b	40.7
T6	NPK briquette: N_{78} (two-2.4 g)	51.71bc	63.03cd	61.38b	28.38bc	89.76b	69.8
T7	Urea briquette: N_{104} (two-1.8 g)	58.71ab	74.17ab	72.59ab	31.47abc	104.1ab	66.2
T8	NPK briquette: N_{102} (two-3.4g)	58.71ab	67.23bc	70.35ab	34.95ab	105.3ab	68.7
CV (%)		10.87	8.36	10.38	19.60	10.30	-

Within a column, numbers followed by the same letters are not significantly different by LSD at the 5% level of significance; CV (%) = Coefficient of variation.

Table 8. Effect of Prilled Urea, Urea Briquettes and NPK Briquettes on the Uptake and Recovery of N by BRRI Dhan 28 Under AWD Condition

Trt. No.	Description	N Uptake		N Uptake at Harvest			% of N Recovery
		PI	Heading	Grain	Straw	Total	
		(kg/ha)		(kg/ha)			
T1	Check: N_0	18.18e	21.09e	25.62e	7.74b	33.36e	-
T2	Urea briquette: N_{78} (one-2.7 g)	80.32b	88.60b	67.31bc	28.31a	95.62bc	79.8
T3	Urea briquette: N_{156} (two-2.7 g)	92.02a	97.88a	95.89a	29.23a	125.1a	58.8
T4	Prilled urea: N_{78}	44.96d	50.22d	48.95d	14.60b	63.56d	38.7
T5	Prilled urea: N_{156}	55.44c	66.17c	65.48bc	28.07a	93.55bc	38.6
T6	NPK briquette: N_{78} (two-2.4 g)	54.80c	68.80c	57.60cd	28.15a	85.75c	67.2
T7	Urea briquette: N_{104} (two-1.8 g)	78.03b	83.92b	75.33b	26.87a	102.2b	66.2
T8	NPK briquette: N_{102} (two-3.4g)	73.66b	82.29b	69.28b	25.49a	94.77bc	60.3
CV (%)		7.97	7.24	8.97	21.88	9.19	-

Within a column, numbers followed by the same letters are not significantly different by LSD at the 5% level of significance; CV (%) = Coefficient of variation.

Bangladesh Rice Research Institute

Ammonium N Concentration in Flood Water

The NH_4-N concentration in water samples under different fertilizer treatments at BRRI is shown in Figure 4- Figure 8. As at BAU, NH_4-N concentration in water was observed higher under plots with prilled urea (T4, T5 and T7). In all three samplings, the highest NH_4-N concentration of water was observed on day 2 of prilled urea application and then decreased steadily over time. NH_4-N concentration in water was found much lower in urea briquette and NPK briquette deep placement plots in all three samplings. However, relatively higher NH_4-N was observed in T3 (urea briquette-N_{104}) at day 2 of its application compared to other treatments. Nevertheless, the concentration was much lower when it compared the concentration observed after prilled urea application (Figure 4) that was applied as basal, 10 days before briquette application. This indicates that broadcast application of prilled urea in rice fields produces higher NH_4-N concentration in water, which consequently causes higher N loss and more water pollution compared with urea briquette and NPK briquette deep placed.

Figure 8 illustrates the NH_4-N concentration in floodwater observed after broadcasting of prilled urea at three different application times. At all application times the NH_4-N concentration was highest two days after N top dressed applications.

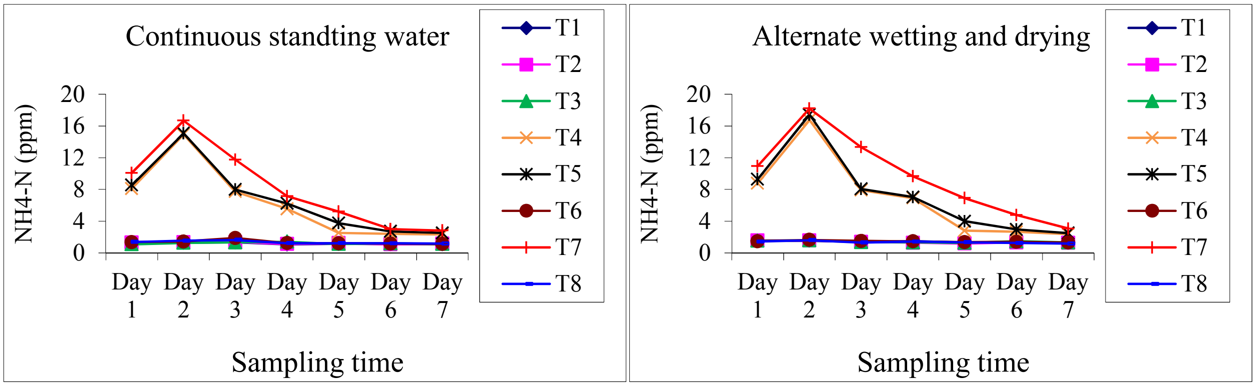


Figure 4. Changes in NH_4-N concentration of water in CSW and AWD conditions after basal application of fertilizer (first sampling), all the fertilizers were applied as basal except urea and NPK briquette

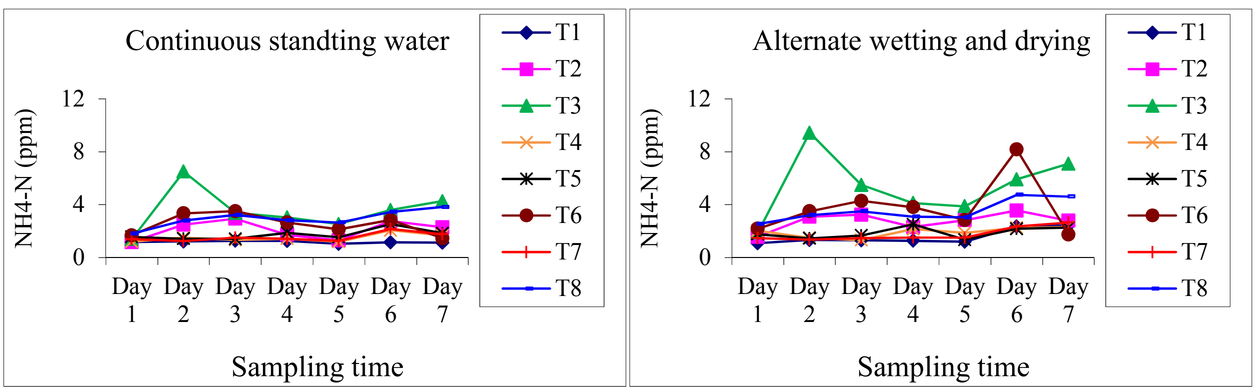


Figure 5. Changes in NH_4-N concentration of water in CSW and AWD conditions after application of urea briquette and NPK briquette (second sampling); Note: Prilled urea was applied during land preparation as basal and not applied during briquette application

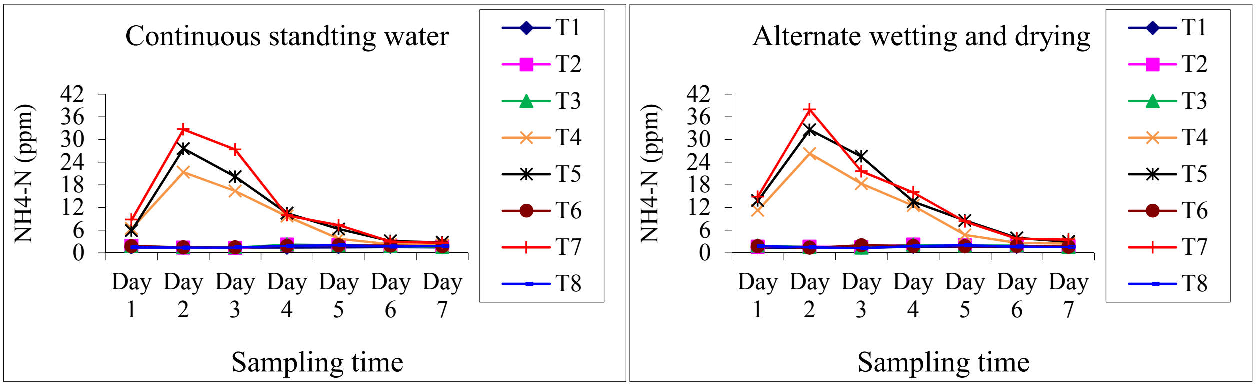


Figure 6. **Changes in NH_4-N concentration of water in CSW and AWD conditions after first top dressing of prilled urea (third sampling)**

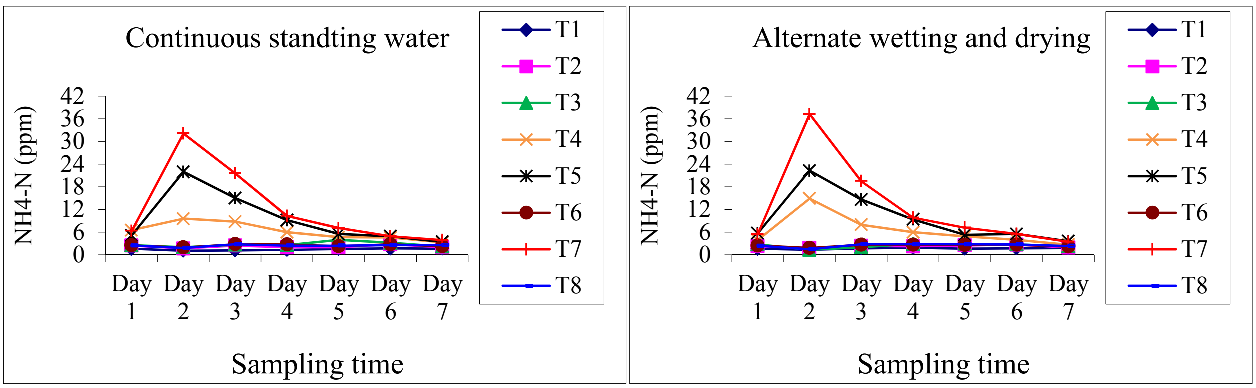


Figure 7. **Changes in NH_4-N concentration of water in CSW and AWD conditions after second top dressing of prilled urea (fourth sampling)**

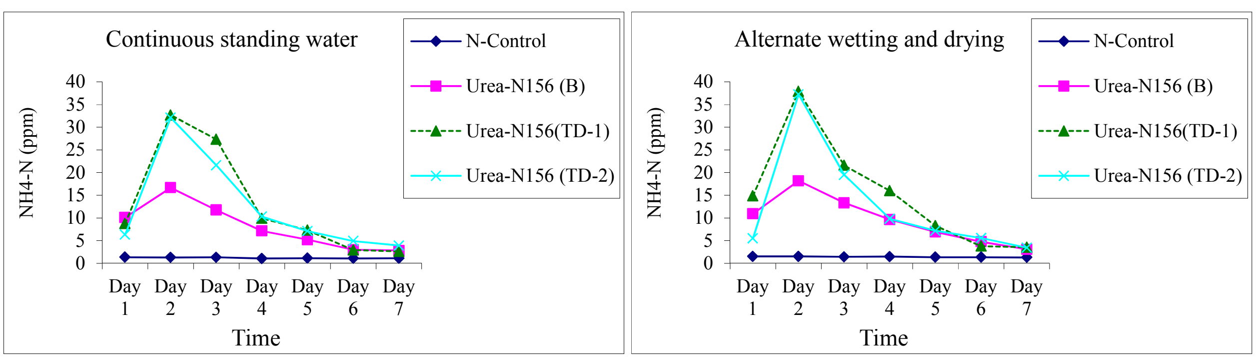


Figure 8. **Changes in NH_4-N Concentration of Water in CSW and AWD Conditions After Application of Urea as Basal (B) and Top Dress (TD) at 156 kg N/ha**

Biomass and Rice Yield

Biomass Weight at Maximum Tillering and Heading Stages

Biomass weight at both maximum tillering and heading stages and grain yield is presented in Table 9 and Table 10. The highest biomass weight was observed in T8 (NPK briq-N_{102}) at both maximum tillering and heading stages under both AWD and CSW conditions.

Grain Yield

There was no significant difference in grain yield between fertilizer treatments. Nitrogen at the rate of 78 kg/ha produced yield of 5.10 t/ha and 5.08 t/ha for AWD and CSW conditions, respectively (Table 9 and Table 10). The grain yield of 4.37 and 4.01 t/ha for CSW and AWD from check treatments at BRRI was much higher than 2.30 and 2.42 t/ha for CSW and AWD, respectively at BAU. This may explain the lack of differences among N fertilizer treatments at BRRI.

Table 9. Effect of Prilled Urea, Urea Briquettes and NPK Briquettes on the Biomass and Grain Yield of BRRI Dhan 28 AWD Condition

Trt. No	Description	Dry Matter Yield		Grain Yield
		Maximum Tillering	Heading	
		(t/ha)		(t/ha)
T1	Check-N_0	1.20	4.41	4.01
T2	Urea briquette-N_{78} (one 2.7g)	2.11	6.72	5.09
T3	Urea briquette- N_{104} (two 1.8g)	1.92	7.21	4.98
T4	Prilled urea-N_{78}	2.02	6.15	5.10
T5	Prilled urea-N_{104}	1.77	6.67	4.87
T6	NPK briquette-N_{78} (two 2.4g)	2.03	7.20	5.11
T7	Urea-N_{156}	2.22	7.76	4.92
T8	NPK briquette-N_{102} (two 3.4g)	3.02	8.31	5.05
LSD-0.05		0.15	0.23	0.58
CV (%)		4.2	9.0	6.9

Table 10. Effect of Prilled Urea, Urea Briquettes and NPK Briquettes on the Biomass and Grain Yield of BRRI Dhan 28 under CSW Condition

Trt. No	Description	Dry Matter Yield		Grain Yield
		Maximum Tillering	Heading	
		(t/ha)		
T1	Check-N_0	1.38	4.67	4.37
T2	Urea briquette-N_{78} (one 2.7g)	1.90	6.19	5.07
T3	Urea briquette- N_{104} (two 1.8g)	2.16	8.29	5.02
T4	Prilled urea-N_{78}	1.97	7.46	5.14
T5	Prilled urea-N_{104}	2.19	8.55	4.85
T6	NPK briquette-N_{78} (two 2.4g)	2.15	7.66	5.02
T7	Urea-N_{156}	2.92	7.50	5.05
T8	NPK briquette-N_{102} (two 3.4g)	2.83	8.68	5.29
LSD-0.05		0.19	0.27	0.49
CV (%)		4.9	2.1	5.6

Nitrogen Uptake

Under AWD condition, the highest N uptake during both maximum tillering and heading stages was observed in NPK briquette (N102) treatment (T8) (Table 11). Similarly, T8 had the highest nitrogen uptake during both growth stages under CSW condition.

Table 11. Total N Uptake at the Maximum Tillering and Heading Stages of BRRI Dhan 28 Under AWD and CSW Condition

		Total N Uptake			
Trt. No	Description	AWD		AWD	
		Maximum Tillering	Heading	Maximum Tillering	Heading
		(kg/ha)			
T1	Check-N_0	20.28	35.87	21.04	28.76
T2	Urea briquette-N_{78} (one 2.7g)	45.74	74.27	40.93	51.96
T3	Urea briquette- N_{104} (two 1.8g)	35.00	92.90	46.21	85.87
T4	Prilled urea-N_{78}	38.66	71.50	34.13	75.25
T5	Prilled urea-N_{104}	40.12	76.56	39.22	96.99
T6	NPK briquette-N_{78} (two 2.4g)	46.67	86.78	45.44	90.08
T7	Urea-N_{156}	44.20	73.94	40.07	72.46
T8	NPK briquette-N_{102} (two 3.4g)	55.34	112.78	47.83	104.52
LSD-0.05		4.23	9.29	4.82	6.59
CV (%)		5.9	6.80	6.9	5.00

Rice Yield and Water Productivity

There was no significant difference in the rice grain yield between CSW and AWD conditions; however, water productivity in terms of grain/kg water was always higher in AWD condition than CSW condition (Table 12). In both conditions, the water productivity remains higher in the fertilized condition than N control treatment. Water productivity is observed higher under AWD (Table 12) as expected.

Table 12. Yield, Water Use and Water Productivity with Respect to Irrigation and Rainfall of *Boro* Rice under AWD Irrigation System

Trt. No	Description	Yield		Water Input		Water Productivity	
		AWD	CSW	AWD	CSW	AWD	CSW
		(t/ha)		(mm)		(g grain/kg water)	
T1	Check-N_0	4.01	4.37	955	1,265	0.42	0.35
T2	Urea briquette-N_{78} (one 2.7g)	5.09	5.07	955	1,265	0.53	0.40
T3	Urea briquette- N_{104} (two 1.8g)	4.98	5.02	955	1,265	0.52	0.40
T4	Prilled urea-N_{78}	5.10	5.14	955	1,265	0.53	0.41
T5	Prilled urea-N_{104}	4.87	4.85	955	1,265	0.51	0.38
T6	NPK briquette-N_{78} (two 2.4g)	5.11	5.02	955	1,265	0.54	0.38
T7	Urea-N_{156}	4.92	5.05	955	1,265	0.48	0.39
T8	NPK briquette-N_{102} (two 3.4g)	5.05	5.29	955	1,265	0.53	0.42

Based on the BAU results on biomass weight at tillering and heading stages, straw and grain yield, N uptake and NH_4-N concentration in floodwater, both urea briquette and NPK briquette showed better performance compared to broadcast application of prilled urea. Moreover, urea briquette applied at 102 kg N/ha (two 1.8g briquette) had significantly higher grain yield and N uptake than urea briquette N78 (one 2.7g). The yield was statistically identical between urea briquette N104 and N156. Hence, increasing dose of urea briquette from one- 2.7g to two-1.8 might be recommended for *boro* season. However, these results are only from one season trial, it should further be verified since the grain yield was not significantly different among N treatments at BRRI. This suggests the site specific need of nitrogen management.

Establishment of Field Trial with GHG Monitoring (*Aus* 2013)

Two field experiments are being conducted during the current *Aus* season 2013 at each of the locations, in the research farms of BAU, Mymensingh and BRRI, Gazipur. The objectives of the studies are to observe the effects of broadcasting prilled urea, UDP and NPK briquette deep placement on: (i) ammonium nitrogen (NH_4-N) concentration in rice field water; (ii) emission of

GHG (N_2O and NO) from the rice field; (iii) rice yield; and (iv) N uptake by rice. The experiments are being conducted in randomized complete block (RCB) design with three replications at both locations. The unit plot size is 5.6 m x 3.6 m at BAU and 4.8 m x 3.2 m at BRRI. Modern rice variety, BRRI Dhan 48 is used at BAU and BRRI Dhan 43 at BRRI as the test crop. One experiment was conducted under CSW condition and the other under AWD condition at both the locations. There were eight treatments in both the experiments as shown in Table 13.

Table 13. Treatment Description for Greenhouse Gas Emission Trial during *Aus* Season 2013

Trt No.	Description	N Rate	P Rate	K Rate	Basal/Deep Placed N	1st Topdress N	2nd Topdress N
		(kg/ha)					
1	Check- N0	0	16[a]	42[b]	0	0	0
2	Urea briquette (one-1.8 g)	52	16[a]	42[b]	52	0	0
3	Urea briquette (one-2.7g)	78	16[a]	42[b]	78	0	0
4	Prilled urea	104	16[a]	42[b]	0	52	52
5	Urea briquette (two-1.8 g)	104	16[a]	42[b]	104	0	0
6	NPK briquette (one-3.4 g)	51	13[c]	32[c]	51	0	0
7	Prilled urea	78	16[a]	42[b]	0	39	39
8	NPK briquette (two-2.4 g)	78	16[d]	42[d]	78	0	0

a. Applied as triple superphosphate.
b. Applied as muriate of potash (KCl).
c. P and K is applied as NPK briquette (Treatment 6).
d. P and K is applied as NPK briquette (Treatment 8).

Fertilizer application schedule and all agronomic management practices will be followed as described under *Boro* 2013 experiment. Thirty-day-old seedlings were transplanted with planting distance 20 x 20 cm on May 24, 2013, at BAU. Twenty three-day-old seedlings were transplanted on June 10, 2013, at BRRI. Prilled urea was applied in two equal splits at 10 and 31 DAT at BAU. At BRRI, first topdressing was also done at 10 DAT but second topdressing has yet to be done. The fertilizer was mixed thoroughly with the soil immediately after application. Urea briquettes and NPK briquettes were applied at 10 DAT. The briquettes were placed at a depth of 8-10 cm between four hills at the alternate rows. Before application of N fertilizers, water was drained out from the field.

Water sampling has been done twice at BAU, the first after basal application of PU and deep placement of urea briquettes and NPK briquettes and the second after topdressing of PU. But at BRRI water sampling has been done once until now after first topdressing of urea. In each sampling, first sample was collected two hours after the application of fertilizers and the subsequent samplings were done for seven consecutive days. Samples are being collected once a day (in the morning) in acid-washed plastic bottles and brought to the laboratory to measure pH and ammonium N concentration.

Plant samples have been collected by destructive sampling from each plot at the PI stage at BAU. At BRRI, plant samples are also supposed to be harvested at PI stage but the crop has not yet attained PI stage. Plant samples at BAU are now under process of chemical analysis.

Measurement of GHG (N_2O and NO) has begun following the installations of the machines at both the locations. Soil and air temperature and soil water potential are also being measured along with the gas measurement.

N Fluxes Measurement from Chambers

There is no N flux data from *Boro* rice, since the installation of gas chambers and gas anlyzers were done only after harvesting of *Boro* rice. Installation of gas chambers in the field and set up of gas analyzers (NO and N_2O analyzers) in the field laboratory were done from May 18 to June 4 at BAU and from June 4 to June 9, 2013, at BRRI. Gas sampling started immediately after completion of installation, (beginning of *Aus* rice experiment at both BAU and BRRI). Emission rates are being calculated. Preliminary fluxes of NO and N_2O from BAU for the month of June 2013 are shown in Figure 9 and Figure 10. The gas sampling systems and gas analyzers are working smoothly in both sites. Calculation of N fluxes will continue, and seasonal comparisons and comprehensive effect of fertilizer deep placement on fluxes will be done after harvesting of the *Aus* rice. Since this is the first measurements taken in this project, it would essentially be for settling the procedures and more stable system will be for *Aman* and *Boro* rice.

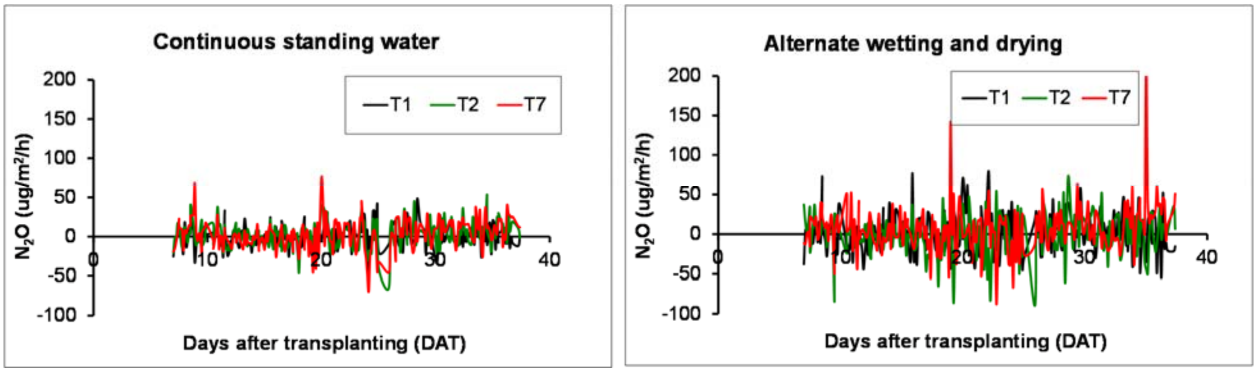


Figure 9. N_2O Fluxes in Control (T1), Broadcasted Urea (T7) and Deep Placed Urea (T2) Plots Under Both CSW and AWD Condition at BAU for the Month of June 2013

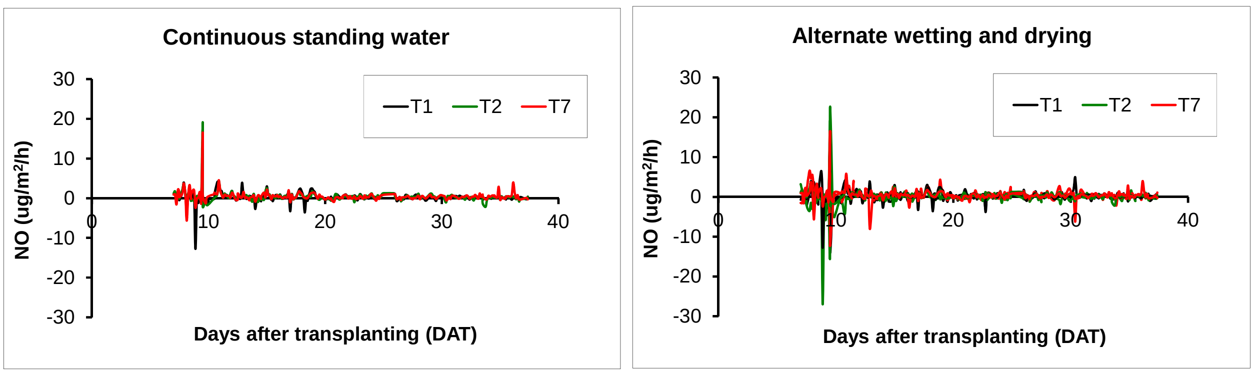


Figure 10. NO Fluxes in Control (T1), Broadcasted Urea (T7) and Deep Placed Urea (T2) Plots Under Both CSW and AWD Condition at BAU for the Month of June 2013

Soil and Air Temperature and Soil Moisture Data

Soil and air temperature and soil moisture data are also monitored along with gas sampling. Air temperature data were used to calculate the emission rates of NO and N_2O. Soil temperature and moisture data are being processed.

Runoff and Leaching Data

Since *Boro* 2012 (December 2011), AAPI has collaborated with BAU and BRRI to establish trials under the GHG project protocols. These trials collected agronomic data, and ammonium N was measured in standing water in each treatment after fertilizer application. The procedure for sampling water in flooded fields was provided by the USAID mission environment officer, and the analysis took place in the laboratory of each institution.

Results for NH_4-N in standing water in the trials for this *Boro* season until March 2013 are presented in Figure 1-Figure 8.

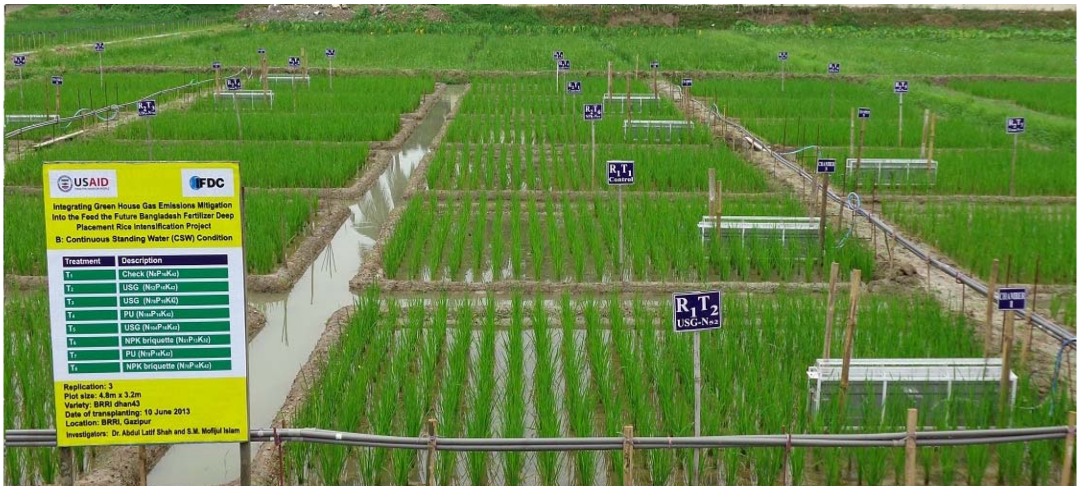
Operating Manual for GHG Measurement

This will be prepared by IFDC.

Bangladeshi Scientists Trained for GHG Measurement

Approval for training in Alabama was requested on November 27, 2012, and approved by USAID/Bangladesh on December 18, 2012. Two junior scientists attended a training program in Alabama from April 6 to May 4, 2013. Their training program is provided in Appendix 2. The local environment specialist and postdoctoral scientist also joined the training from April 12 and April 22, respectively. In-country training and capacity development of junior scientists are going on continously in their respctive institutes with IFDC experts.

Appendix 1. Photographs



Photograph 1 Field view of GHG experiment at BRRI, Gazipur with gas chambers in the field

Photograph 2 Gas measurement instruments in the GHG Laboratory at BAU, Mymensingh

Photograph 3 Prof. Dr. Md. Abdul Khaleque Patwary, Dean, Faculty of Agriculture, BAU formally inaugurated GHG Laboratory at BAU, Mymensingh on behalf of Vice Chancellor of the university

Appendix 2. Training Program for Junior Scientists at IFDC

Program for
Mr. Azmul Huda
Junior Scientist
Department of Soil Science, Bangladesh Agricultural University (BAU)
Mr. Sm Mofijul Islam
Scientific Officer
Bangladesh Rice Research Institute (BRRI)

Greenhouse Gas Training/Orientation for Counterpart Scientists
Conducted by
Dr. Upendra Singh,
Principal Scientist
Systems Modeling (Soil Fertility), Soil and Plant Nutrition
IFDC Office of Programs
and
Dr. Rick Austin
Consultant – Support Services,
IFDC Office of Programs

Sunday, April 7, 2013

8:19 a.m. Arrive Huntsville International Airport
Meet and transport to Residence Inn, Florence, AL – *Mr. Michael O. Thompson, Senior Visitor Relations Officer, Visitor Relations, Office of Human Resources*

Monday, April 8-Friday, April 12, 2013 – Week 1

7:45 a.m. Meet at Residence Inn and transport to IFDC – *Mr. Thompson*

8:00 a.m. IFDC Welcome – *Mr. John Allgood, Director, EurAsia Division; Dr. Upendra Singh and Dr. Rick Austin*

8:15-8:45 a.m. IFDC video – *To Inherit the Earth – A Question of Survival – Mr. Thompson*

9:00 a.m. Meet in the South Conference Room

1. Overview of the GCC (Global Climate Change) integration pilot to the AAPI Project.
2. Introduction and overview of the NO/N_2O gas measuring system.
3. NO analyzer – Function, configuration, calibration and use.
4. N_2O analyzer – Function, configuration, calibration and use.
5. Gas calibration instrument – Function, configuration and use.

4:15 p.m. Return to Residence Inn – *Mr. Thompson*

Monday, April 15-Friday, April 19, 2013 – Week 2

7:45 a.m. Meet at Residence Inn and transport to IFDC – *Mr. Thompson*

8:30 a.m. Meet in the South Conference Room

1. Data logger – Functions and uses.
2. AM16/32B multiplexer – Function, configuration and use.
3. Temperature (air and soil) and soil water potential sensors.
4. 16-Channel AC/DC relay controller – Function and use.
5. Loggernet Software – Programs for writing programs, collecting and viewing data and more.

4:15 p.m. Return to Residence Inn – *Mr. Thompson*

Monday, April 22-Friday, April 26, 2013 – Week 3

7:45 a.m. Meet at Residence Inn and transport to IFDC – *Mr. Thompson*

8:30 a.m. Meet in the South Conference Room

1. In-depth analysis of the IFDC system data logger program.
2. System wiring (in detail) and trouble shooting.
3. Data collection and processing.
4. Practical issues – Plumbing, electrical and gas handling.
5. Digital multi-meter (provided in their tool kit) – Function and use.
6. Construction of a chamber from parts and pieces.

4:15 p.m. Return to Residence Inn – *Mr. Thompson*

Monday, April 29-Friday, May 3, 2013 – Week 4

7:45 a.m. Meet at Residence Inn and transport to IFDC – *Mr. Thompson*

8:30 a.m. Meet in the South Conference Room

1. Installation of software on BRRI and BAU computers.
2. Set up, monitoring and download of data.
3. Hands-on exercises.
4. Analyzing and exporting data for statistical analysis and plotting.

4:15 p.m. Return to Residence Inn Shoals – *Mr. Thompson*

Saturday, May 4, 2013

6:00 a.m. Departure Huntsville International Airport – *Executive Connection*