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

(January-March 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

April 2013

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List of Acronyms

AAPI	Accelerating Agriculture Productivity Improvement
AWD	Alternate Wetting and Drying
BAU	Bangladesh Agricultural University
BRRI	Bangladesh Rice Research Institute
CDCS	Country Development Cooperation Strategy
cm	centimeter
CSW	Continuous Standing Water
FDP	Fertilizer Deep Placement
FTF	Feed the Future
GCC	Global Climate Change
GCCI	Global Climate Change Initiative
GHG	Greenhouse Gas
ha	hectare
IFDC	International Fertilizer Development Center
IRRI	International Rice Research Institute
kg	kilogram
m	meter
MOP	Muriate of Potash
N_2O	Nitrous Oxide
NH_4-N	Ammonium
NO	Nitric Oxide
NPK	Nitrogen, Phosphorus and Potassium
PDB	Power Development Board
psig	pound-force per square inch
RCB	randomized complete block
TSP	Triple Superphosphate
UDP	Urea Deep Placement
USAID	United States Agency for International Development

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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) emission reduction through fertilizer deep placement (FDP) technology, provide opportunities for carbon 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 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 10th 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 second three months – January-March 2013.

Project Description

The GHG Project will measure 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).

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												
• Initial soil characterization	Completed in 2012											
• Establishment of field trial with GHG monitoring						Boro harvest	Aus to be planted					
• N fluxes measurement from chambers												
• Collection of soil and air temperature and soil moisture data												
• Collection of runoff and leaching data												
• 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 BAU Soil Science Department and the BRRI Soil Science Division effective November 1, 2012, with an anticipated completion data 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, 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 obtained their U.S. visas after receiving international travel approval from USAID. Both scientists departed for the United States on April 6 to return to Bangladesh on May 6.

Appointment of AAPI Staff

The position of resident expert – post doc was approved April 9. The position of local environment specialist was appointed on April 7.

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

Procurement, Calibration and Shipment

The system to measure nitric oxide (NO) and N_2O was custom built at IFDC headquarters, Alabama, USA. It requires (for each site) 12 chambers to be placed over fertilizer treatments within the rice field trials. The system works on a three-hour cycle. It is controlled and data is 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.

This equipment has been procured, assembled, packed and shipped. It arrived in Dhaka in two shipments, the first on March 26 and the second on March 29. Its clearance through customs is proving to be time-consuming. It is expected to be cleared close to the end of April.

Each site requires calibration gases of high purity. These are being procured locally through Linde Bangladesh Limited through a special order that normally requires three months of lead time. An order for gases, regulators, valves and spare parts was placed with Linde on December 11, 2012. Linde advised that the order will arrive in Bangladesh on March 13, 2013. However, it did not reach as expected. The latest date for arrival of gases to the site is May 12, 2013.

An air compressor, maximum pressure 125-175 pound-force per square inch (psig), and a storage tank of 25 cubic feet with a built-in regulator to set the output pressure of 70 psig will be purchased locally. Cost quotes have been collected. This is an off-the-shelf item. Quotes have been collected and evaluated and the preferred supplier selected for its purchase to coincide with equipment installation in May.

Setup and Installation at Relevant Institutes with Scientists

Both BAU and BRRI have assigned land to accommodate the field trials for the duration of the project. Both have approved construction of field laboratories to house the equipment, and both have appointed their resident engineers to liaise with AAPI and its contractor for the construction of the field laboratories.

Field Laboratories

Construction started on December 23, 2012, at BRRI and December 24, 2012, at BAU. 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. The buildings will receive final inspection by the AAPI engineer, along with the BAU and BRRI engineer at their respective sites, scheduled for April 13. After final inspection, the buildings will be handed over on April 18, 2013.

A backup generator is required for both BAU and BRRI. Cost quotations were sought, and the preferred supplier was selected on February 10, 2013. This will be an off-the-shelf purchase, and the work order will be issued to allow delivery after the completion of the building and before the installation of the equipment. It is expected that the generator will be installed by April 24, 2013.

Installation of Equipment

Installation of equipment will commence when the junior scientists, local environment specialist and post doc return from training on May 6, 2013. The principal research scientist from IFDC will also be on-site for one month to oversee the installation and calibration of the equipment. This will coincide with the *Boro* harvest.

Initial Soil Characterization

Both institutions have completed soil analysis of their sites (BAU in January 2012 and BRRI in February 2012).

Establishment of Field Trial with GHG Monitoring

Trial protocols were prepared by IFDC in collaboration with BAU and BRRI scientists.

Greenhouse Gas Emission Trial at Bangladesh Agricultural University

Two field experiments were set up at BAU, Mymensingh, during the *Boro* season of 2013 to study the effects of broadcast urea, urea deep placement (UDP) and NPK deep placement on ammonium (NH_4-N) concentration in rice field water, yield and N uptake using the high-yielding variety BRRI dhan28 as the crop. One experiment was provided full irrigation to keep the plots flooded. Alternate wetting and drying (AWD) was practiced on the other. There were eight treatments with three replications in each. The experiments were laid out in randomized block design. The unit plot size was 6 meters (m) x 4 m. The fertilizers were applied as per Table 3.

Table 3. Treatment Description for Greenhouse Gas Emission Trial at Bangladesh Agricultural University *Boro* Season 2013

Trt. No.	Description	N Rate (kg/ha)	P Rate (kg/ha)	K Rate (kg/ha)	Basal/Deep-Placed N (kg/ha)	1st Topdress N (kg/ha)	2nd Topdress N (kg/ha)
1	Check	0	25[a]	64[b]	0	0	0
2	UDP (one 2.7 g)	78	25[a]	64[b]	78	0	0
3	UDP (two 2.7 g)	156	25[a]	64[b]	78	0	0
4	Urea broadcast	78	25[a]	64[b]	26	26	26
5	Urea broadcast	156	25[a]	64[b]	52	52	52
6	NPK (two 2.4 g)	78	16[c]	42[c]	78	0	0
7	UDP (two 1.8 g)	104	25[a]	64[b]	104	0	0
8	NPK (two 3.4 g)	102	25[d]	64[d]	102	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).

All the treatments except T6 and T7 received 25 kilograms (kg) P and 64 kg K/hectare (ha) from triple superphosphate (TSP) and muriate of potash (MOP), respectively. Sulfur was applied to all plots at the rate of 20 kg/ha from gypsum. Rice seedlings were transplanted in the plots on January 31, 2013, maintaining a spacing of 20 centimeters (cm) x 20 cm. Prilled urea was applied in two splits on February 10 and March 3, and a third split will be applied on March 24, 2013. Urea and NPK briquettes were applied on February 10, 2013. Before application of N fertilizers, the water in the rice plots was drained out. Prilled urea was applied to the fields and mixed with the soils. The urea and NPK briquettes were placed at an 8-10 cm depth between four hills at alternate rows. The irrigation water was added to all plots and the depth of water was measured. Water samples from all plots were collected in acid-washed plastic bottles. The temperature of the water was recorded. The collected water samples were brought to the laboratory for measuring pH and ammonium concentration.

Results

The ammonium concentration in water of prilled urea treated plots (T4 and T5) varied widely at both sampling times as indicated in Figure 1-Figure 4. In both the two samplings, the highest ammonium concentration of water of T4 and T5 treatments were observed on day 2 after application of prilled urea and then steadily decreased with time. The ammonium concentrations in other treatments did not vary widely. The ammonium concentration in the urea deep placement (UDP)-treated plots (T2, T3 and T7) showed low concentration of ammonium nitrogen at the first sampling time while during second sampling it was negligible.

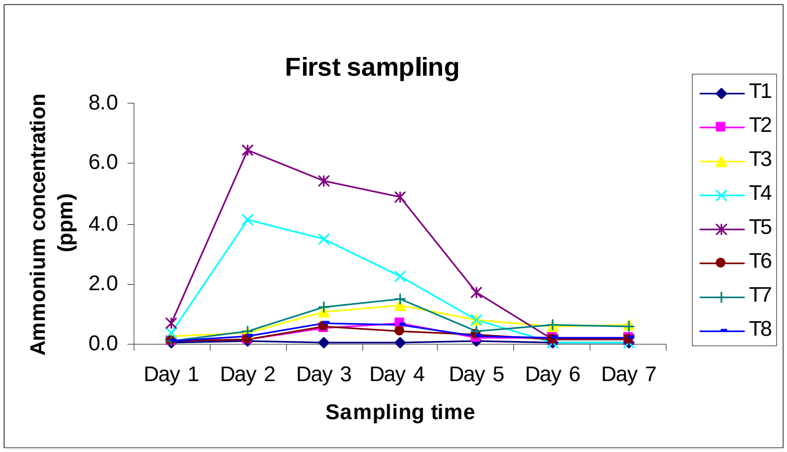

Figure 1. Changes in Ammonium Concentration of Water in Fully Irrigated Condition at Different Treatments (February 10-16, 2013)

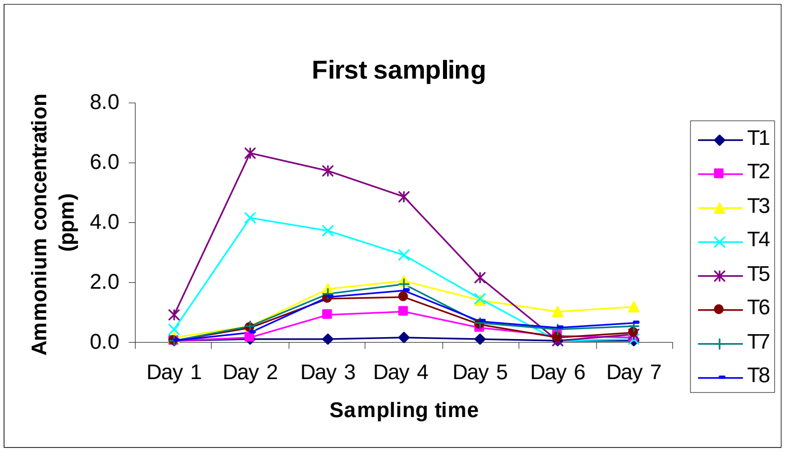

Figure 2. Changes in Ammonium Concentration of Water in Reduced Irrigated Condition at Different Treatments (February 10-16, 2013)

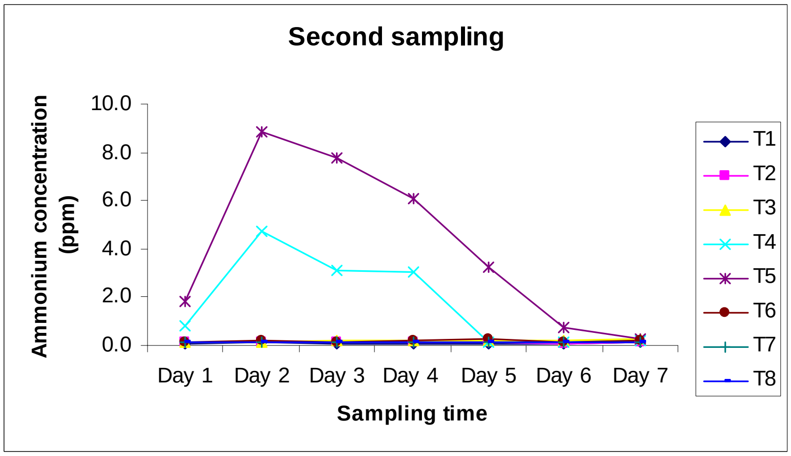

Figure 3. Changes in Ammonium Concentration of Water in Fully Irrigated Condition at Different Treatments (March 3-9, 2013)

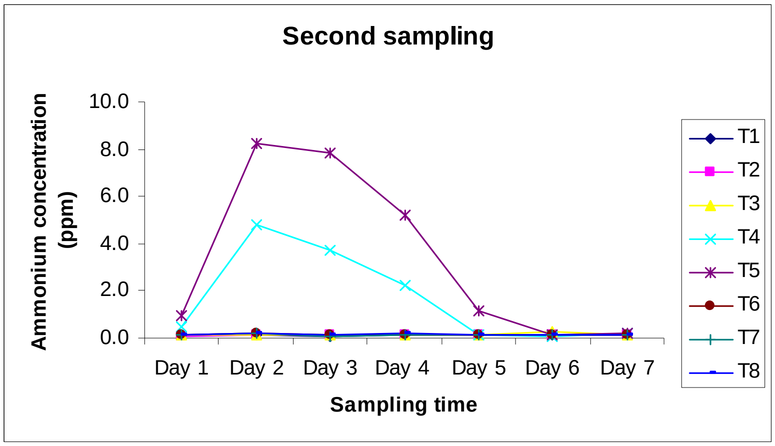

Figure 4. Changes in Ammonium Concentration of Water in Reduced Irrigated Condition at Different Treatments (March 3-9, 2013)

Greenhouse Gas Emission Trial at Bangladesh Rice Research Institute

Two field experiments were set up at a BRRI farm in Gazipur on February 10 and 11, 2013, (Experiment 1 in AWD condition and Experiment 2 in continuously wet condition). The experimental design was randomizied complete block (RCB) with six replications having eight treatments in both conditions. All P, K and 1/3 urea-N were applied at the time of transplanting in respective treatments. Urea and NPK briquettes were placed in respective treatments on February 20, 2013, in both the experiments. A 40-day-old seedling of BRRI dhan28 was transplanted in the front three replications; for the remaining three replications, the seedling's age was 76 days in both the experiments. Perforated PVC pipe (10 cm diameter) was placed in Experiment 1 to measure the wetting and drying cycle of the experiment. The length of PVC pipe was 25 cm with 15 cm perforated and leaving a 10 cm upper portion. The 15 cm perforated portion was placed into the soil and all soil was removed from the inside. The water level was measured on alternate days. Irrigation was given when the water level fell to the bottom of the pipe (15 cm from the soil surface). Water was collected from all treatments in all experiments to determine NH_4–N after basal and UDP placement time of both the experiments.

It was observed that the NH_4-N content in floodwater was higher in 1/3 of urea applied as basal than in urea and NPK briquettes applied as deep placement at 78 kg N and 104 kg N/ha in both the experiments (Figure 5-Figure 8).

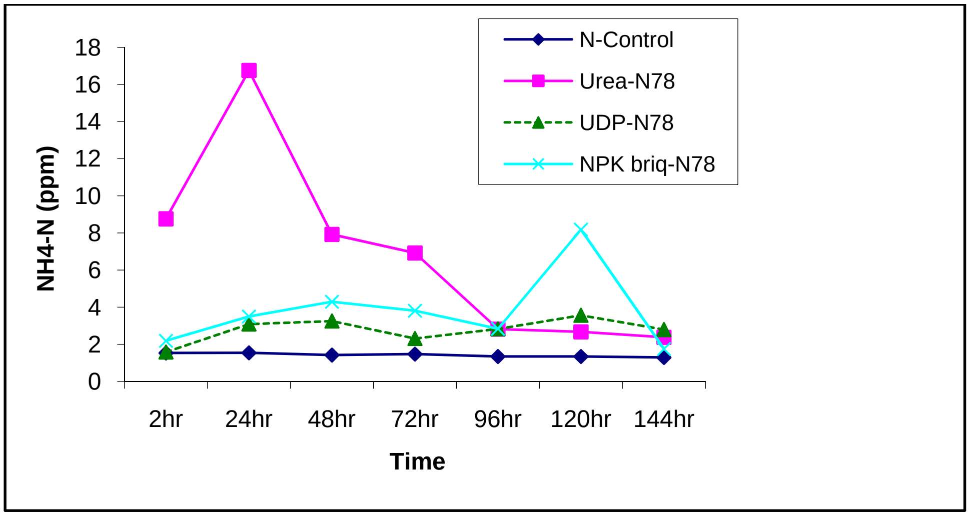

Figure 5. **NH_4-N Content in Floodwater Under Alternate Wetting and Drying (AWD) Condition After Application of Different N Sources at 78 kg N/ha**

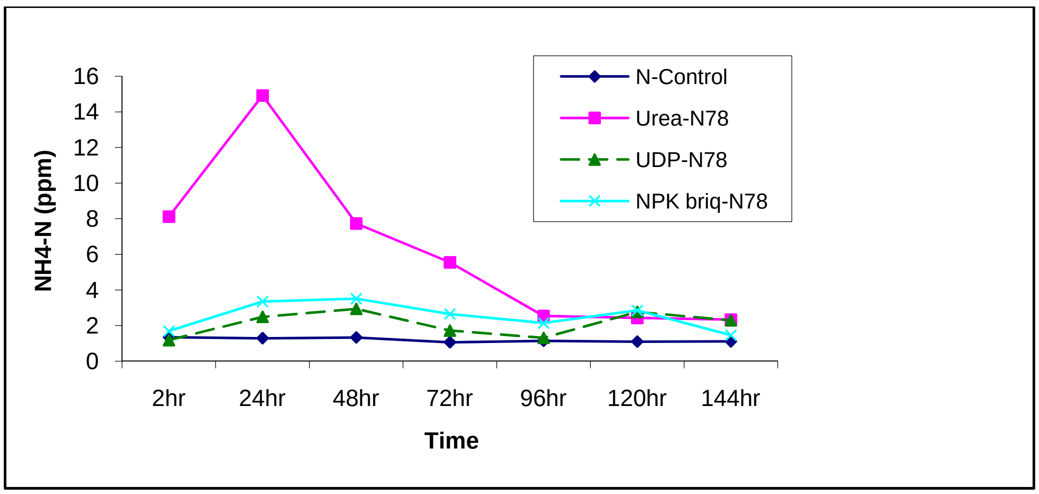

Figure 6. **NH_4-N Content in Floodwater Under Continuous Standing Water (CSW) After Application of Different N Sources at 78 kg N/ha**

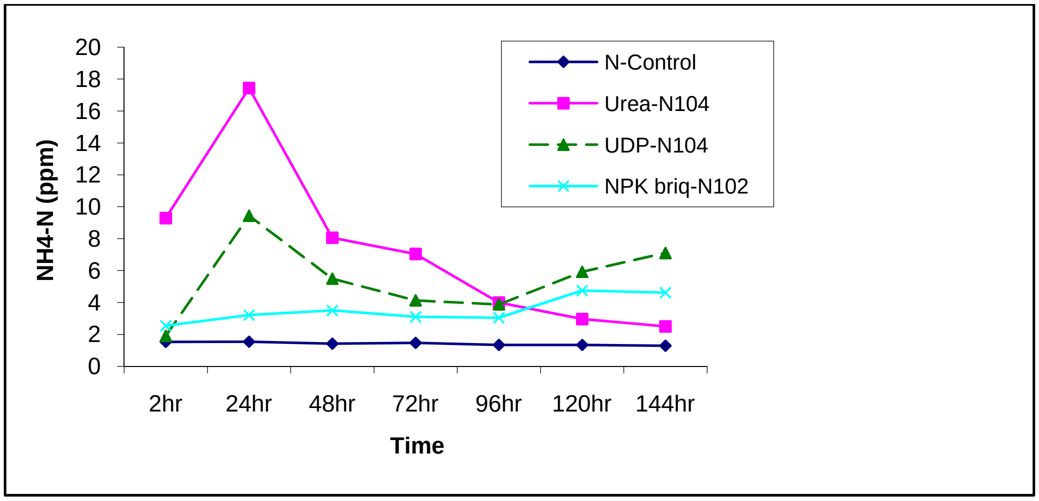

Figure 7. **NH_4-N Content in Floodwater Under Alternate Wetting and Drying (AWD) Condition After Application of Different N Sources at 104 kg N/ha**

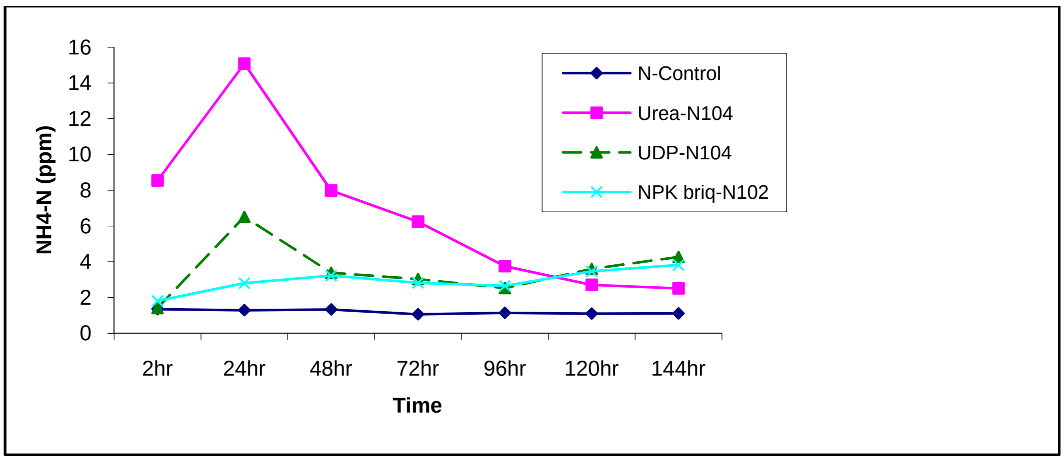

Figure 8. **NH_4-N Content in Floodwater Under Continuous Standing Water (CSW) After Application of Different N Sources at 104 kg N/ha**

The first topdressing has been applied, samples collected and analysis underway, which will be reported next quarter.

N Fluxes Measurement from Chambers

Equipment installation will occur from May 14, 2013. The *Boro* rice crop will likely be harvested in late May 2013 or early June 2013 (depending on the weather). Any measurements taken would essentially be for settling the procedures. This will allow the system to be ready for the *Aus* season that will be planted in mid-June 2013.

Soil and Air Temperature and Soil Moisture Data

This will follow the same timetable as N fluxes measurement from chambers.

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 ammonium 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 when the equipment is installed.

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. Each trainee received a visa and departed Bangladesh on April 6. Their training program is provided in Appendix 1. They will be joined by the local environment specialist who departed Bangladesh on April 12 and the post doc who has a tentative travel plan for April 20.

Appendix 1. 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, Office of Programs
and
Dr. Rick Austin,
Consultant – Support Services, 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*