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Competitive Research Grant

Sub-Project Completion Report

on

Delineating of rice yield limiting soil factors for some selected paddy soils of Bangladesh

Project Duration
May 2017 to September 2018

Soil Science Division
Bangladesh Rice Research Institute, Joydebpur, Gazipur-1701

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Acronyms

PCR	Project Completion Report
CRG	Competitive Research Grant
AEZ	Agro Ecological Zone
OC	Organic carbon
OM	Organic Matter
Ca	Calcium
K	Potassium
Na	Sodium
Fe	Iron
Mn	Manganese
Cfu	Colony forming unit
Cu	cupper
ha	hectare
Mg	Magnesium
Meq	Milli equivalent
N	Nitrogen
NFB	Free living N_2 fixing bacteria
g	Gram
P	Phosphorus
pp	Procurement plan
ppm	Parts per million
PSB	Phosphate Solubilizing Bacteria
R/S	Regional Station
S	Sulfur
t	Tone
Zn	Zinc
LSD	Least Significant Difference
cm	Centimeter
Wt.	weight
CL	Critical Limit

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Executive Summary

The yield of rice is crucial for food security of Bangladesh, a densely populated country in the world. Its population is increasing day by day resulting increased food demand. Although rice is staple food, yield is dormant for a considerable time. Researchers are trying to increase rice yield or break down yield ceiling condition. Understanding the relationships between rice yield and soil properties such as physical, chemical and biological are of critical importance in modern rice cultivation. Researchers have recently shown interest in characterizing soil variability in relation to crop growth and yield. Interactions of soil mineral elements with plants are either antagonistic or synergistic depending on their availability and ratios in rhizosphere. The native soil nutrient ratios before crop culture varied widely depending on nature of soil ecology and cropping intensity in different localities of Bangladesh and thus causing either nutrient deficiency or toxicity. The relationships of indigenous soil nutrients ratios with rice crop yield are yet to be fully explored.

The yield of same rice variety varied with different locations. According to BRRI annual report 2012-13, BRRI dhan29 gives 9 t/ha in single cropped area of Habiganj and Bhanga but in Gazipur and Rangpur it produces around 6 t/ha. The variation of yield offers us a great opportunity to conduct research and find out indigenous soil nutrient ratios, yield limiting soil factors and the relationship of nutrient ratios with rice yield. Soil samples from 0-20 cm depth were collected from Gazipur (AEZ 28), Habigonj (AEZ 21), Rangpur (AEZ 3) and Bhanga (AEZ 12) both wet and dry season. Collected soil was analyzed for find out indigenous soil nutrient ratios and thus established first pot experiment, finally correlation was calculated between rice yield and indigenous nutrient ratios for delineating of rice yield limiting of soil factors of studied location. Another pot experiment was done by treatment on the basis of initial soil test results. From first pot experiments (without fertilizer) in T.Aman and Boro season, we found AEZ 21 and AEZ 12 soils performed significantly better than other soils (AEZ 28 and AEZ 3) in respect of agronomic attributes. High organic matter percentage, high Nitrogen, potassium and Sulpher content was found in AEZ 21 and AEZ 12 soils. Our result indicated that grain yield was the highest in AEZ-21 and AEZ 12 compared to other studied locations might be because of favorable C:N, C:K, N:K and S:Zn ratios for fine textured soil. In second pot experiment, we tried to improve the soils of AEZ 28 and AEZ 3 region by adding nutrients and organic matter which were sufficient in AEZ 21 and AEZ 12 soils. Though there was no significant difference but some improvement were observed in AEZ 28 and AEZ 3 soils considering agronomic performance. Microbial populations were also high in AEZ 21 and 12compared to AEZ 28 and 3 studied soils.

Soil separates (Sand, silt and clay) showed variable relationships with indigenous nutrient ratios in different AEZ. It is concluded that OM, N, K and S may be the main yield limiting soil factors of AEZ 21 and AEZ 12 soils and indigenous soil nutrient ratios play a vital role in improving rice yield.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Delineating of rice yield limiting soil factors for some selected paddy soils of Bangladesh
2. **Implementing organization:** Bangladesh Rice Research Institute
3. **Principal Investigator**: Dr. Mosud Iqbal, Senior Scientific Officer, Soil Science Division, Bangladesh Rice Research Institute, Mobile: 01742996798, Email: miqbalbrri@gmail.com
   Co-principal investigator: Md. Nayeem Ahmed, Scientific Officer, Soil Science Division, Bangladesh Rice Research Institute, Mobile: 01717562149 Email: nayeembrri@gmail.com
4. **Sub-project budget** (Tk):
   4.1 Total: 2465985/- (Twenty four lac sixty five thousand nine hundred eighty five only)
   4.2 Revised (if any): _____
5. **Duration of the sub-project:**
   5.1 Start date (based on LoA signed): May 2017
   5.2 End date: 30 September 2018
6. **Justification of undertaking the sub-project:**
   The yield of rice is crucial for food security of Bangladesh, a densely populated country in the world. Its population is increasing day by day resulting increased food demand. Although rice is staple food, yield is stagnant for a considerable time. Researchers are trying to increase rice yield or break down yield ceiling condition. On the other hand yield of same variety varied with different locations. According to [2-3] BRRI dhan29 gives 9 t/ha in single cropped area of Habiganj and Faridpur but in Gazipur and Rangpur it produces around 6 t/ha. This variation of yield offers us a great opportunity to conduct research and find out indigenous soil nutrient ratios and thus yield limiting soil factors. If we can establish any relationship between rice yield and soil physical, chemical and biological properties responsible for higher yield then it will be key finding to increase rice yield in other locations of the country.
7. **Sub-project goal:** Increase rice yield all over the Bangladesh.
8. **Sub-project objective (s):**
   - To identify rice yield limiting factors of selected paddy soils in Habiganj (AEZ 21), Bhanga (AEZ 12), Rangpur (AEZ 3) and Gazipur (AEZ 28).
   - To find out indigenous soil nutrient ratios for some selected paddy soils of Bangladesh and establish relationship between nutrient ratios with rice yield.
   - To find out microbial activities in soils of specific locations.
9. **Implementing location (s):** Gazipur

10. Methodology:

Soil samples from 0-20 cm depth was collected from Gazipur (AEZ 28), Habigonj (AEZ 21), Rangpur (AEZ 3) and Bhanga (AEZ 12) using global positioning system (GPS) record along with plot history. Collected samples were analyzed for physical, chemical and biological properties. Soil physical properties such as soil texture chemical properties such as soil pH, organic matter, and available form of all macro and micro nutrients, biological properties was determined following the standard methods described in fertilizer recommendation guide 2012. After soil analysis two pot experiments was conducted in net house one is same condition in collected soil from four locations with same variety to know the yield limiting soil factors. Another pot experiment was done by treatment on the basis of initial soil test results. On the basis of soil analysis data comparison of different locations soil was made to find out the hidden reason of higher yield. The indigenous soil nutrient ratios was found out by comparing results of pot experiments.

The pot experiment was done in Randomized Complete Block Design (RCBD) with sufficient number of replications. The treatments of the first pot experiment was set as T_1= Habiganj soil, T_2= Faridpur soil, T_3= Gazipur soil and T_4= Rangpur soil) to know yield limiting soil factors. Second pot experiment treatments was T_1= Habigonj soil + Amendment as requirement, T_2= Faridpur soil + Amendment as requirement, T_3= Gazipur soil + Amendment as requirement and T_4= Rangpur soil + Amendment as requirement) to establishment of proper nutrient ratio. Amendment was done by applying fertilizer or manure to create same soil condition for all treatments.

11. Results and discussion:

T. Aman 2017 (Wet Season)

Initial soil characteristics and nutrient ratios under wet season

Soils collected (T.Aman, 2017) from Gazipur (AEZ 28), Habigonj (AEZ 21), Rangpur (AEZ 3) and Bhanga (AEZ 12) were analysed in laboratory of Soil Science Division, BRRI, Gazipur prior to pot experiment set up. Results were presented in table 1. From the analysis we found highest OC(%), total N (%), available S and Mn content in Habiganj soils, highest P and Fe in Rangpur soils, highest K and Ca in Bhanga soils and highest Na and Cu content in Gazipur soils. The native soil nutrient ratios before crop culture varied widely depending on nature of soil ecology and cropping intensity in different localities of Bangladesh [1]. In AEZ-21 and AEZ 28, the C:P, C:K, N:P, N:K ratios and Ca:P ratio in AEZ 28 were the widest compared to other studied locations (Table 6). We found widest C:P, N:P and Ca:P ratios, these clearly pointed out that soils of specific locations were deficient in P. In case of AEZ 21, no beneficial effect of added P was recorded. This indicating that P analysis method used failed to determine available soil P [3]. The C:N ratios ranged from 9.4 to 10.8. The P:Zn ratio was the lowest in AEZ-28 and N:P, Ca:Zn and Ca:P ratios were the lowest in AEZ-3. The S:Zn ratios were lowest in AEZ 28 and AEZ 3 but highest P:Ca ratio was highest in AEZ 3 (table 6).

Rice yield and nutrient ratios

Moreover soils of habiganj region (AEZ 21) performed best over other studied regions in respect of agronomic characteristics. Highly significant grain weight per pot (44.2g/pot) was observed in habiganj soils when experiment was conducted without fertilizer management showed in table 2. That means habiganj soils content some characteristics like high OC, N, S and Mn which influenced yield of rice. In

second pot experiment we managed soils of Bhanga, Rangpur and Gazipur by adding nutrients which were lack in these soils from habiganj. The results of second pot experiment indicate slightly improved performance of soils of Bhanga, Rangpur and Gazipur than first pot experiment though there is no significance difference (table 3). The correlation coefficients were calculated between rice yield and indigenous soil nutrient ratios presented in table 7. In haor ecosystem (Habiganj, AEZ-21), most of the indigenous soil nutrient ratios were non significant (C:K, N:K, N:Mg, N:Zn, P:K etc) or negatively significant (C:N, C:P, N:P, Ca:P etc) but only K:Ca showed significant positive correlations with wet season rice yield (Table 7). P:K ratio was synergistically related with grain yield but C:N, K:Mg, Ca:Zn, ratios antagonistically and other ratios (C:P, C:K, N:P S:Zn etc) acted non significant in AEZ-3 (flash flood and cold prone areas). In AEZ-28 and 12, C:N, C:P,N:Mg and N:Zn showed significant positive correlations with rice yield. Our result indicated that grain yield was the highest in AEZ-21 compared to other studied locations might be because of favorable C:N, C:K, N:K and S:Zn ratios for fine textured soil [1](Table 2). The favorable C:N, C:K, N:K and S:Zn indicates optimum soil C, N, K and Zn availability.

We also collected 15 soil samples (0-15 cm) each from respective locations for detailed study. After laboratory analysed results were showed in the following table 4. We found highest OC (%), total N (%), available S content in Habiganj soils like as pot soils. Microbial Population (cfu/g soil) of soils collected from different location were presented in the table 5. Total Bacteria, Fungus and PSB were highest in Habiganj soils. We concluded that for AEZ 21 high OC ,N and S content is the yield limiting soil factors for wet season rice cultivation.

Table 1. Initial soil (0-15cm) characteristics of the studied soils (Pot experiment), T.Aman, 2017

Parameter	Gazipur AEZ 28	Rangpur AEZ 3	Habiganj AEZ 21	Bhanga AEZ 12	CL*
1. Soil texture	Silty Clay Loam	Silty Loam	Silty Clay Loam	Silty Clay	--
2. Soil pH (1:2.5)	6.2	5.9	6.41	6.83	--
3. OC (%)	1.06	1.35	1.61	1.28	C:N=10:1
4. Total N (%)	0.12	0.11	0.14	0.13	0.12
5. Olsen P (ppm)	1.08	6.73	2.35	4.37	8.0
6. Available K (meq/100g soil)	0.09	0.22	0.12	0.29	0.12
8. Available S (ppm)	32.7	36.2	38.1	37.1	10.0
9. Available Ca (%)	0.18	0.03	0.06	0.32	
10. Available Na (ppm)	136	70	70	73	
11. Available Mg (ppm)	435	485	403	470	
11. Available Zn (ppm)	5.6	3.3	6.1	4.1	
12. Available Mn (ppm)	7.7	22.8	58.1	4.1	
13. Available Fe (ppm)	35	134	122	102	
14. Available Cu (ppm	6.0	3.5	3.9	3.2	

* Fertilizer Recommendation Guide, BARC, 2012

Table 2. Agronomic attributes of BRRI dhan49 at different studied soils (without Fertilizer management), T.Aman,2017

Soils	Plant height (cm)	Tiller no/pot	Panicle no/pot	Panicle length (cm)	1000 grain wt. (g)	Grain weight/pot (g)	Straw weight/pot (g)
Gazipur	88	18	17	19.7	22.4	19.7	29.3
Rangpur	91.3	19	16	19.9	23.3	19.5	28.0
Habiganj	91.3	37	34	20.6	21.8	44.2	50.8
Bhanga	82	20	18	19.3	21.7	20.2	32.5
$LSD_{0.05}$	5.4	5	5	1.8	1.8	7.5	4.9

Table 3. Agronomic attributes of BRRI dhan49 at different studied soils (After fertilizer managment), T.Aman,2017

Soils	Plant height (cm)	Tiller no/pot	Panicle no/pot	Panicle length (cm)	1000 grain wt. (g)	Grain weight/pot (g)	Straw weight/pot (g)
Gazipur	89.7	29	27	22.7	21.7	50.5	34.4
Rangpur	90.7	30	27	22	21.8	56.7	40.1
Habiganj	92	33	31	23.7	21.6	67.9	46.6
Bhanga	92	27	25	22.3	22.4	50.6	31.0
$LSD_{0.05}$	2.9	1.5	1	1.5		6.7	7.1

Table: 4. Soil properties of collected soils from different locations other than pot experiment, T.Aman 2017

Parameter	Gazipur AEZ 28	Rangpur AEZ 3	Habiganj AEZ 21	Bhanga AEZ 12	CL
Soil texture	Silty Clay Loam, Silty Loam, Silty Clay , Clay	Loam, Silty Loam, Silty Clay Loam and Clay Loam	Silty Clay Loam, Clay Loam, Silty Clay, Loam, Clay	Clay, Silty Clay	
Soil pH (1:2.5)	6.0-6.9	5.7-6.4	5.2-6.4	6.1- 7.0	
*OC (%)	1.5 (0.1)	1.2 (0.1)	1.9 (0.2)	1.3 (0.1)	<0.95
Total N (%)	0.09 (0.02)	0.09 (0.01)	0.20 (0.02)	0.12 (0.05)	0.12
Olsen P (ppm)	17.9 (9.1)	44.6 (6.0)	17.9 (4.4)	21.0 (6.6)	8.0
Exch. K (meq/100g soil)	0.11 (0.01)	0.12 (0.01)	0.15 (0.01)	0.33 (0.02)	0.12
Available S(ppm)	9.84 (0.86)	7.46 (0.23)	16.82 (2.64)	10.07 (1.0)	10
Available Ca (%)	0.12 (0.01)	0.04 (0.01)	0.07 (0.01)	0.29 (0.01)	0.04
Available Na (ppm)	58.88 (3.45)	60.96 (3.28)	65.30 (1.89)	82.39 (13)	-
Available Zn (ppm)	4.48 (0.52)	4.17 (0.42)	3.01 (0.30)	2.94 (0.54)	0.6
Available Mn (ppm)	5.35 (0.78)	33.17 (4.47)	18.34 (5.88)	6.60 (1.12)	1.0
Available Fe (ppm)	94.96 (5.55)	120.78 (4.09)	32.87 (12.0)	124.65 (3.9)	3.0
Available Cu (ppm)	4.42 (0.50)	3.93 (0.20)	4.55 (0.19)	3.27 (0.15)	0.2

***(Standard deviation)**

Table 5. Microbial Population (cfu/g soil) of soils collected from different location of Bangladesh, T.Aman 2017

Soil Sample	Total Bacteria	Fungus	Phophate Solubilizing Bacteria	Nitrogen Fixing Bacteria
Expt. soil (Habiganj)	$1.36x10^{8}$	$6.79x10^{4}$	$2.26x10^{4}$	$2.26x10^{3}$
Expt. Soil (Rangpur)	$2.84x10^{7}$	$9.45x10^{3}$	$1.61x10^{4}$	$5.67x10^{3}$
Expt. soil (Bhanga)	$2.82x10^{7}$	$9.41x10^{3}$	$1.88x10^{4}$	$1.22x10^{4}$
Expt. soil (Gazipur)	$1.08x10^{5}$	$5.17x10^{4}$	$5.17x10^{3}$	$3.10x10^{4}$

Table 6. Native soil nutrient ratio of the studied soils (Pot experiment), T.Aman, 2017

Sand%	Silt%	Clay%	C:N	C:P	C:K	N:P	N:K	N:Mg	N:Zn	P:K	P:Zn	K:Ca	K:Mg	Ca:P	Ca:Zn	S:Zn
Habiganj (AEZ 21)																
15.81	54	30.19	10.8	5578.6	356.7	517.3	33.2	3.74	251	0.064	0.485	0.072	0.11	218	105	6.85
Bhanga (AEZ 12)																
3.09	42	54.91	10.3	2201.5	112.9	213.3	10.9	2.63	287	0.051	1.353	0.035	0.24	554	747	8.71
Gazipur (AEZ 28)																
13.09	48	38.91	9.4	5018.4	301.5	534.3	32.1	2.59	218	0.060	0.409	0.020	0.08	850	345	6.28
Rangpur (AEZ 3)																
27.81	54	18.19	9.5	1403.2	129.8	147.0	13.6	2.39	217	0.092	1.476	0.285	0.18	38	56	6.44

Table: 7. Relationships of nutrient ratios with T.Aman rice yields

	Habiganj (AEZ 21)	Bhanga (AEZ 12)	Gazipur (AEZ 28)	Rangpur (AEZ 3)
C:N	-0.6598*	0.6074*	0.9929**	-0.6541*
C:P	-0.6599*	0.7502*	0.8260**	-0.1722NS
C:K	0.2042NS	0.9775**	0.3268NS	0.1188NS
N:P	-0.6373*	0.5722NS	0.7309*	0.2205NS
N:K	0.5676NS	0.7632*	-0.1526NS	0.5001NS
N:Mg	0.5435NS	0.9052**	0.6430*	-0.1105NS
N:Zn	0.3545NS	0.8204**	0.8069**	0.1165NS
P:K	0.5689NS	-0.3328NS	-0.4916NS	0.8795**
P:Zn	0.3598NS	-0.3035NS	0.2179NS	-0.0663NS
K:Ca	0.9953**	-0.9902**	0.8109**	-0.1715NS
K:Mg	-0.6169*	0.9910**	0.5668NS	-0.8553**
Ca:P	-0.8671**	0.4880NS	0.4963NS	-0.1236NS
Ca:Zn	-0.9000**	-0.1069NS	0.9738**	-0.6424*
S:Zn	-0.5639NS	0.2207NS	0.9997**	-0.1062NS

NS = Non significant; * = Significant at 5% level; ** = Significant at 1% level of probability

Boro, 2017-18 (Dry season)

Indigenous soil characteristics and nutrient ratios

Prior to Boro 2017-18 soils were collected from Gazipur (AEZ 28), Rangpur (AEZ 3), Habiganj (AEZ21) and Bhanga (AEZ 12) for pot experimentation and laboratory analysis. Pot experiment soils were collected and analyzed separately. Initial soil characteristics were presented in table 8. Soil texture and soil pH of Habiganj and Bhanga soils were clay loam, clay and 6.7, 6.8 respectively. Other essential plant nutrients (OC, N, P, K, S and other macro and micro nutrients) are high in these soils compared to Gazipur and Rangpur Soils (Table 8). The native soil nutrient ratios before crop culture varied widely depending on nature of soil ecology and cropping intensity in different localities of Bangladesh (table 13). In Habiganj (AEZ 21), C:P, N:P and Ca:P ratios were the widest compared to Bhanga (AEZ 12) and Rangpur (AEZ 3). These clearly indicated that soils were deficient in P in studied location. But previous studies showed no beneficial effect of added P in AEZ 21 [3] indicating that P analysis method used failed to determine available soil P. Similar ratios of C:P, N:P and Ca:P were also found in Gazipur (AEZ 28) because of lower soil P levels. Since the study location (AEZ 28) are in high temperature and precipitation in tropical region, high P leaching and P occlusion might have taken place [4-6] [16-18]. The C:N ratio ranged from 9.76 to 12.57. The C:K, N:K and P:K ratios were higher in AEZ 28 and AEZ 3 because of lower soil K levels (Table 13). Indigenous soil nutrient availability and ratios influence crop production in different ecosystem depending on crop variety and water management [1]. Our result indicated that grain yield was the lowest in AEZ 28 and AEZ 3 compared to other studied locations (table 9) might be because of unfavourable C:N and S:Zn ratios [7]. The lower S:Zn ratio indicates higher soil Zn availability might have affected S uptake and thus reduced rice yield [8].

Rice yield and nutrient ratios

In AEZ-12, C:N, C:P, C:K, N:P, N:K, N:Mg, N:Zn, K:Mg, Ca:P, Ca:Zn and S:Zn ratios showed significantly negative relationships with grain yield but significantly positive with P:K ratio. The P:Zn and K:Ca ratios had no significant relationships with grain yield of rice. The C:P, K:Ca and S:Zn, ratios favored significantly rice grain yield in AEZ-3. Nonetheless, N:K, N:Zn, P:K, P:Zn, K:Ca, Ca:P and Ca:Zn ratios acted negatively against rice yield. In AEZ-28, rice yields were influenced antagonistically by C:K, N:P, N:K, P: K, N:Mg and S:Zn ratios but others were synergistically correlated. In AEZ 21 (haor ecosystem), only C:K and N:Mg showed significant antagonistic relationship with Boro rice grain yield but other nutrient ratios had no significant relationships (Table 14). The findings of present investigation shows that indigenous soil nutrient ratios like C:P, K:Ca, S:Zn, P:Zn, K:Ca, K:Mg and Ca:Zn as vital component for dry season irrigated rice yield improvement in flash flood and cold prone areas (AEZ-3) and AEZ 28 regions of Bangladesh (Table 14)

Nutrient Ratios and Soil Separates

We also collected 25 soil samples from each studied location for detailed study. All soils were analyzed (Physical, Chemical and Biological) in Soil Science laboratory and presented in table 11. Different textural class and pH range were found in same location soils. Highest OC(%), N(%), P, K, S and other macro nutrients were found in AEZ 21 and 12 soils. There was much variation in micro nutrients content in studied soils. Highest Zn was found in AEZ 28 but Fe, Mn content highest in AEZ 21 and Cu highest in AEZ 12 region soils of Bangladesh (Table 11). Microbial populations were also high in AEZ 21 and 12compared to AEZ 28 and 3 studied soils (Table 12). In AEZ-21, silt fraction showed significant positive relationship with C:P, N:P and Ca:P ratios. There was significant negative relation of silt with P:Zn and Ca:P with sand fraction (Table 15). Clay fraction had significant positive relationship with C:N, N:Mg, and K:Mg ratios but only K:Ca ratio was negatively correlated in AEZ 12. Moreover C:K, N:P, N:K ratios showed significant positive relations with silt fraction but negative with K:Ca but in case of sand fraction positive significant relation was found with K:Ca. Sand fraction of AEZ 12 showed significant negative relation with C:K, N:Mg, K:Mg (Table 16). The C:K, N:K and N:Mg showed significant negative relations with sand fraction in AEZ-28. However, Ca:P, ratio was positively related with clay separate (Table 17). No significant relationships of soil nutrient ratios with Clay, sand and silt separates were found in AEZ 3 (Table 18). Soil K and Mg showed no effective linkages with sand, silt and clay fractions of studied locations in Bangladesh (Tables 15, 16, 17, 18). [9] also reported that K:Mg was not influenced by chemical, physical, and biological fertility of soil.

Table 8. Initial soil (0-15cm) characteristics of the studied soils (Pot experiment), Boro, 2017-18

Parameter	Gazipur AEZ 28	Rangpur AEZ 3	Habiganj AEZ 21	Bhanga AEZ 12	CL*
1. Soil texture	Silty Clay Loam	Silty Loam	Clay Loam	Clay	--
2. Soil pH (1:2.5)	6.5	6.2	6.7	6.8	--
3. OC (%)	1.54	1.20	3.88	2.27	C:N=10:1
4. Total N (%)	0.13	0.12	0.38	0.20	0.12
5. Olsen P (ppm)	3.43	32.17	5.51	25.22	8.0
6. Available K (meq/100g soil)	0.07	0.23	0.59	0.58	0.12
8. Available S (ppm)	20.05	12.03	55.5	58.25	10.0
9. Available Ca (%)	0.13	0.07	0.14	0.22	
10. Available Na (ppm)	13.9	15.7	150	147	
11. Available Mg (ppm)	410	538	395	430	
12. Available Zn (ppm)	2.3	1.9	3.7	2.4	
13. Available Mn (ppm)	26.3	19.5	63.7	10.4	
14. Available Fe (ppm)	98	273	519	310	
15. Available Cu (ppm	6.3	4.2	6.8	11.7	

* Fertilizer Recommendation Guide, BARC, 2012

Table 9. Agronomic attributes of BRRI dhan58 at different studied soils (without Fertilizer management), Boro, 2017-18

Soils	Plant height (cm)	Tiller no/pot	Panicle no/pot	Panicle length (cm)	1000 grain wt. (g)	Grain wt./pot (g)	Straw wt./pot (g)
Gazipur	82.7	14	13	21. 1	20.0	24.0	19.0
Rangpur	80.5	16	15	20.6	22. 1	29.7	27.6
Habiganj	95.5	47	44	22. 1	21.3	54.3	52.3
Bhanga	98.4	44	40	22.6	20.3	48.6	46.7
$LSD_{0.05}$	3.0	3	3	0.6	0.9	3.5	3. 1

Table 10. Agronomic attributes of BRRI dhan58 at different studied soils (After fertilizer management),Boro, 2017-18

Soils	Plant height (cm)	Tiller no/pot	Panicle no/pot	Panicle length (cm)	1000 grain wt. (g)	Grain wt./pot (g)	Straw wt./pot (g)
Gazipur	93.6	42	39	24.7	20.7	63.1	75.1
Rangpur	90.5	44	41	25.0	22.7	57.6	82.3
Habiganj	100.3	63	61	22.8	21.8	101.0	125.4
Bhanga	100.7	53	52	24.9	21.0	103.3	119.6
$LSD_{0.05}$	2.9	4.6	4.7	0.8	0.9	14.5	13.5

Table: 11. Soil properties of collected soils from different locations other than pot experiment, Boro 2017 -18

Parameter	Gazipur AEZ 28	Rangpur AEZ 3	Habiganj AEZ 21	Bhanga AEZ 12	CL
Soil texture	Silty Clay Loam, Silty Loam, Silty Clay and Clay	Silty Loam, Loam, Silty Clay Loam and Sandy Clay	Clay Loam, Sandy Clay Loam, Clay, Loam, Sandy Clay, Sandy Loam and Silty Loam	Clay	--
Soil pH (1:2.5)	6.2-7.2	5.9-6.8	6.2-7.1	6.3- 7.3	--
*OC (%)	1.17 (0.05)	1.19 (0.06)	2.49 (0.16)	2.43 (0.05)	C:N= 10:1
Total N (%)	0.12 (0.02)	0.13 (0.01)	0.25 (0.03)	0.23 (0.02)	0.12
Olsen P (ppm)	4.25 (0.6)	28.1 (3.3)	4.4 (0.4)	22.6 (1.7)	8.0
Exch. K (meq/100g soil)	0.11 (0.01)	0.11 (0.01)	0.30 (0.02)	0.59 (0.01)	0.12
Available S(ppm)	12.9 (0.13)	16.7 (1.6)	61.3 (6.5)	64.6 (8.8)	10.0
Available Ca (%)	0.08 (0.01)	0.06 (0.01)	0.09 (0.01)	0.21 (0.01)	
Available Na (ppm)	58.88 (3.45)	60.96 (3.28)	68 (10)	305 (11)	
Available Mg (ppm)	205 (10)	352 (15)	149 (7)	273 (137)	
Available Zn (ppm)	4.83 (1.09)	0.63 (0.10)	2.65 (0.27)	2.01 (0.27)	0.6
Available Mn (ppm)	37.33 (7.09)	3.35 (0.39)	38.02 (6.70)	23.85 (8.42)	1.0
Available Fe (ppm)	207 (19)	278 (22)	498 (37)	261 (20)	3.0
Available Cu (ppm)	5.36 (0.17)	4.16 (0.17)	5.08 (0.32)	12.83 (0.42)	0.2

***(Standard deviation)**

Table: 12. Microbial Population (cfu/g soil) of soils collected from different location of Bangladesh, Boro 2017-18

Soil Sample	Total Bacteria	Fungus	Phophate Solubilizing Bacteria	Nitrogen Fixing Bacteria
Expt. Soil (Habiganj)	$2.1x10^{8}$	$1.3x10^{6}$	$2.26x10^{4}$	$7.6x10^{4}$
Expt. Soil (Rangpur)	$3.1x10^{7}$	$4.5x10^{5}$	$1.61x10^{4}$	$2.5x10^{4}$
Expt. soil (Bhanga)	$3.9x10^{7}$	$9.4x10^{5}$	$1.88x10^{4}$	$5.1x10^{4}$
Expt. soil (Gazipur)	$3.2x10^{7}$	$4.3x10^{5}$	$5.17x10^{3}$	$2.8x10^{4}$

Table: 13. Native soil nutrient ratio of the studied soils (Pot experiment), Boro, 2017-18

Sand%	Silt%	Clay%	C:N	C:P	C:K	N:P	N:K	N:Mg	N:Zn	P:K	P:Zn	K:Ca	K:Mg	Ca:P	Ca:Zn	S:Zn
Habiganj (AEZ 21)																
43.81	18	38.19	10.34	2230.93	54.14	215.97	5.24	3.01	321.62	0.02	1.49	0.16	0.57	252.09	375.41	15.00
Bhanga (AEZ 12)																
24.37	20.72	54.91	10.93	463.44	51.48	52.74	5.86	3.09	554.17	0.11	10.51	0.10	0.53	86.04	904.17	24.27
Gazipur (AEZ 28)																
10.37	54.72	34.91	12.57	3525.05	412.24	346.94	40.57	2.90	517.39	0.12	1.49	0.02	0.07	379.01	565.22	8.72
Rangpur (AEZ 3)																
12.37	66.72	20.91	9.76	488.60	167.27	34.82	11.92	2.08	589.47	0.34	16.93	0.13	0.17	21.76	368.42	6.33

Table:14. Relationships of nutrient ratios with Boro rice yields

	Habiganj (AEZ 21)	Bhanga (AEZ 12)	Gazipur (AEZ 28)	Rangpur (AEZ 3)
C:N	-0.2757NS	-0.77977*	0.802052**	0.487251NS
C:P	0.423039NS	-0.91961**	0.325519NS	0.900584**
C:K	-0.99998**	-0.87081**	-0.99751**	-0.36993NS
N:P	0.395457NS	-0.94178**	-0.22872NS	-0.14104NS
N:K	0.046907NS	-0.98198**	-0.8924**	-0.61115*
N:Mg	-0.8678**	-0.73681*	-0.88555**	-0.56654NS
N:Zn	0.145603NS	-0.90748**	0.721419*	-0.95492**
P:K	-0.49081NS	0.944412**	-0.5114NS	-0.9998**
P:Zn	-0.04485NS	-0.5529NS	0.741846*	-0.99216**
K:Ca	0.376742NS	-0.13239NS	0.960769**	0.967139**
K:Mg	-0.59357NS	-0.60147*	0.921269**	-0.19678NS
Ca:P	0.117233NS	-0.9958**	0.006149NS	-0.90145**
Ca:Zn	-0.21071NS	-0.79347*	0.696984*	-0.95644**
S:Zn	-0.0135NS	-0.86445**	-0.39726NS	0.826296**

NS = Non significant; * = Significant at 5% level; ** = Significant at 1% level of probability

Table: 15. Nutrient ratios as influenced by soil separates, Habiganj (AEZ 21), Boro season

	Clay	Sand	Silt
C:N	0.0233 NS	-0.0282 NS	0.0070 NS
C:P	-0.2516 NS	-0.3716 NS	0.5627 **
C:K	-0.1982 NS	-0.1956 NS	0.3515 NS
N:P	-0.2478 NS	-0.3583 NS	0.5469 **
N:K	-0.2026 NS	-0.1950 NS	0.3546 NS
N:Mg	0.1523 NS	0.1945 NS	-0.3118 NS
N:Zn	-0.0448 NS	0.3586 NS	-0.3008 NS
P:K	0.0006 NS	0.0963 NS	-0.0914 NS
P:Zn	0.1169 NS	0.3488 NS	-0.4277 *
K:Ca	-0.2401 NS	0.3954 NS	-0.1711 NS
K:Mg	0.1733 NS	0.2515 NS	-0.3833 NS
Ca:P	-0.0222 NS	-0.4820 *	0.4737 *
Ca:Zn	0.1013 NS	0.1503 NS	-0.2272 NS
S:Zn	-0.2733 NS	0.3637 NS	-0.1132 NS

NS = Non significant; * = Significant at 5% level; ** = Significant at 1% level of probability

Table: 16. Nutrient ratios as influenced by soil separates, Bhanga (AEZ 12), Boro season

	Clay	Sand	Silt
C:N	0.5322**	-0.3253 NS	-0.2249 NS
C:P	0.0663 NS	-0.2732 NS	0.3697 NS
C:K	0.2346 NS	-0.4716*	0.4619*
N:P	-0.0975 NS	-0.1587 NS	0.4143*
N:K	-0.0637 NS	-0.2464 NS	0.5146**
N:Mg	0.6986**	-0.8009**	0.3438 NS
N:Zn	-0.0697 NS	-0.1650 NS	0.3843 NS
P:K	0.0090 NS	0.0484 NS	-0.0961 NS
P:Zn	-0.0480 NS	0.0085 NS	0.0559 NS
K:Ca	-0.4565*	0.6461**	-0.4345*
K:Mg	0.7818**	-0.7864**	0.1971 NS
Ca:P	0.1321 NS	-0.2903 NS	0.3023 NS
Ca:Zn	0.0380 NS	-0.2362 NS	0.3480 NS
S:Zn	-0.1235 NS	0.1851 NS	-0.1353 NS

NS = Non significant; * = Significant at 5% level; ** = Significant at 1% level of probability

Table: 17. Nutrient ratios as influenced by soil separates, Gazipur (AEZ 28), Boro season

	Clay	Sand	Silt
C:N	-0.2465 NS	0.1944 NS	0.1078 NS
C:P	0.2260 NS	-0.1561 NS	-0.1278 NS
C:K	0.1375 NS	-0.4294*	0.3601 NS
N:P	0.3556 NS	-0.2662 NS	-0.1741 NS
N:K	0.2352 NS	-0.4524*	0.2467 NS
N:Mg	0.3282 NS	-0.4443*	0.0994 NS
N:Zn	0.0960 NS	-0.1544 NS	0.0611 NS
P:K	0.1014 NS	-0.3247 NS	0.2761 NS
P:Zn	-0.1138 NS	-0.0290 NS	0.2052 NS
K:Ca	-0.1043 NS	0.3128 NS	-0.2561 NS
K:Mg	0.2634 NS	-0.1461 NS	-0.1958 NS
Ca:P	0.4126*	-0.3735 NS	-0.1174 NS
Ca:Zn	0.1224 NS	-0.1937 NS	0.0737 NS
S:Zn	-0.0106 NS	0.0876 NS	-0.0990 NS

NS = Non significant; * = Significant at 5% level; ** = Significant at 1% level of probability

Table: 18. Nutrient ratios as influenced by soil separates, Rangpur (AEZ 03), Boro season

	Clay	Sand	Silt
C:N	0.3187 NS	-0.3602 NS	0.3064 NS
C:P	0.1568 NS	-0.0868 NS	0.0453 NS
C:K	0.1792 NS	-0.3520 NS	0.3466 NS
N:P	0.1370 NS	-0.0666 NS	0.0289 NS
N:K	0.1342 NS	-0.2997 NS	0.3017 NS
N:Mg	0.2138 NS	-0.0513 NS	-0.0164 NS
N:Zn	-0.1359 NS	0.0127 NS	0.0336 NS
P:K	-0.0194 NS	-0.1437 NS	0.1745 NS
P:Zn	-0.2212 NS	0.1312 NS	-0.0742 NS
K:Ca	-0.0235 NS	0.0622 NS	-0.0641 NS
K:Mg	-0.1576 NS	0.2084 NS	-0.1868 NS
Ca:P	0.0706 NS	0.0480 NS	-0.0812 NS
Ca:Zn	-0.2710 NS	0.1800 NS	-0.1132 NS
S:Zn	-0.2664 NS	0.2895 NS	-0.2427 NS

NS = Non significant; * = Significant at 5% level; ** = Significant at 1% level of probability

12. Research highlight/findings (Bullet point – max 10 nos.):

- Significant differences of agronomic attributes were observed in Habiganj (AEZ21) and Bhanga soils over Rangpur (AEZ 3) and Gazipur (AEZ 28) when rice plant was grown without fertilizer management. But some improved agronomic performance were observed in AEZ 3 and AEZ 28 after soil management.
- High organic matter, high Nitrogen and Sulfur content was found in Habiganj (AEZ 21) soils.
- High organic matter, high Nitrogen and available potassium and Sulfur were found in Bhanga (AEZ 12) soils.
- High microbial population (Bacteria, fungus, Phosphate Solubilizing Bacteria and Nitrogen Fixing Bacteria) were found in Habiganj and Bhanga soils.
- Micronutrient status of Habiganj and Bhanga soils was better than Gazipur and Rangpur soils.
- Indigenous soil nutrient ratios showed variable relationships with wet and dry season rice yield in different AEZ.
- Grain yield was the lowest in AEZ 28 and AEZ 3 compared to other studied locations might be because of unfavourable C:N and S:Zn ratios
- Soil separates (Sand, silt and clay) showed variable relationships with indigenous nutrient ratios in different AEZ in dry season.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	**5**	**125000**	**5**	**123500**	Price re-fixed as per BRRI Procurement committee
1. Desktop computer	1	60000	1	59000	
2. Laser Printer	1	20000	1	19800	
3. UPS (offline)	1	10000	1	9800	
4. Scanner	1	10000	1	10000	
5. Digital camera	1	25000	1	24900	
(b) Lab &field equipment	**2**	**260000**	**2**	**259000**	
1. Hot plate	1	110000	1	109000	
2. Distilled water plant	1	150000	1	150000	
(c) Office furniture	**9**	**64500**	**9**	**63500**	
1. Executive chair	2	20000	2	20000	
2. Visitor chair	4	16000	4	14000	
3. Computer chair	1	3500	1	3000	
4. Computer table	1	5000	1	5000	
5. File cabinet	1	20000	1	21500	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Hot Plate	1	100%			
Distilled water plant	1	100%			
Office equipments			5	100%	
Office furniture			9	100%	

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	-	-	-		
(b) Workshop	45	20	65	1 day	Honorable PD of the NATP was the chief guest

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	570485	570090	468438	101652	82	
B. Field research/lab expenses and supplies	820000	680272	655255	25017	96	
C. Operating expenses	186000	156254	144344	11910	92	
D. Vehicle hire and fuel, oil & maintenance	200000	195598	184000	11598	94	
E. Training/workshop/seminar etc.	120000	108000	106660	1340	99	GoB fund not found
F. Publications and printing	90000	76500	0	76500	0	PCR cost return to BARC,NATP-2
G. Miscellaneous	30000	25300	19550	5750	77	
H. Capital expenses	449500	456797	452675	4122	99	
Total	2465985	2268811	2030922	237889	90	

D. Achievement of Sub-project by objectives: (Tangible form)

Narrative Summary (NS)	Objectively Verifiable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions (IA)
Goal Increase rice yield all over the Bangladesh	✓ Rice yield limiting soil factors identified (at least one factor) and rice yield increasing through its use. ✓ Nutrient ratio determined	✓ Baseline report ✓ Evaluation report ✓ Project report	✓ Good linkage between researchers, extension personnel and farmers.
Project Purpose/objectives ✓ Identification of rice yield limiting soil factors ✓ Determining appropriate nutrient ratio for maximum rice yield	Rice yield increase	✓ Survey report ✓ Research report	✓ Extension personnel will disseminate new research findings among farmers. ✓ Farmers will applied new research findings for rice production ✓ Political consistency
Outputs Rice yield limiting soil factors and appropriate nutrient ratio for yield maximization will be available for researchers, extension personnel and farmers	Rice yield limiting soil factors and appropriate nutrient ratio for yield maximization will be determined	✓ Project completion report ✓ Progress report ✓ Report of field survey/visit	✓ Climatic and social environment will be favorable for disseminating new research findings among farmers. ✓ Political consistency
ACTIVITIES i) Benchmark study and site selection for soil collection ii) Recruitment and training of project stuff iii) Initial soil analysis and data documentation iv) Set up pot experiments using selected paddy soils v) Pot soils and plant nutrient analysis and correlation analysis	**Inputs (budget in Taka)** i) Staff salary: 570485 ii) Research cost: 820000 iii) Operational expense: 186000 iv) Vehicle hire, R&M: 200000 v) Workshop/seminar: 120000 vi) Publication & printing: 90000 vii) Miscellaneous: 30000 viii) Capital expense: 449500 **Total: 2465985**	i) Report prepared and submitted ii) Publication of major findings	i) Project activities started and completed in time ii) Fund allocation and release in time iii) Climatic condition will remain normal iii) Government policy will remain rivals of constant

among the attributes of soils and plant vi) Decisions will be taken comparing soil analysis data and results of pot experiments vii) Progress report and project final report will prepare viii) Organize workshops			

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Information development	1		Rice yield limiting soil factors of Habiganj and Bhanga has developed.
Other publications, if any	-		

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity)

Rice yield limiting soil factor

High organic matter percentage, high Nitrogen, Potassium and Sulfur content was the main yield limiting soil factors of Habiganj and Bhanga soils.

- All soil analysis data will be helpful for future research and development.
- Rice yield limiting soil factors of Habiganj and Bhanga will be useful for yield improvement of other parts of Bangladesh.
- Soil micronutrient analysis data is a good documentation for future research.
- These findings are based on pot experiment; hence these will be a good indication for future field experimentation.

iii. Technology transferred that help increased agricultural productivity and farmers' income

Rice yield limiting soil factors of Habiganj and Bhanga

iv. Policy Support

Increase of rice yield all over the country

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring[description & output of consultation meeting, monitoring workshops/seminars etc.):

Monitoring team	Date(s) of visit	Total visit till date (No.)	Remarks
Internal Monitoring by Technical Division/ Unit, BARC	16th May, 2018	1	Highly Satisfied
Internal Monitoring by Technical Division/ BRRI	24 March,15 April, 8 June 2018	3	Highly Satisfied

ii) Field Monitoring (time& No. of visit, Team visit and output):

Monitoring team	Date(s) of visit	Total visit till date (No.)	Remarks
Visitors: 1) Head, Soil Science Division BRRI	24 March, 15 April, 8 June 2018	3	Highly Satisfied

H. Problems/Constraints:

i) Fund release from two separate sources (RPA and GoB) is not available in time.
ii) Monthly fund adjustment from RPA and GoB is quite difficult.

I. Lesson Learned/Challenges (if any)

i) Rice yield limiting soil nutrients
ii) Micronutrient status of Bangladesh rice soils
iii) Native soil nutrient ratios of rice soils
iv) Microbiological population status of some selected paddy soils of Bangladesh.

J. Challenges (if any)

These findings are based on pot experimentation. Our future challenge is field implementation of our findings.

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal

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Appendix

App. Table 1: Some basic information of soil samples collected from different farmers field of Rangpur, T.Aman 2017

AEZ No.	Location	Sample No. (0-15 cm)	GPS Reading	Land Type	Soil Series	Soil Textural Class	Land Use
03	Mithapukur	1	25°39.658'N 89°16.966'E	Medium high land	Polashbari	Clay Loam	Boro-Fallow-T.Aman Potato-Boro-T.Aman Maize-T.Aus-T.aman Potato-Maize-T.Aman Tobacco-Fallow-T.Aman Vegetable-Jute-T.Aman
		2	25°38.265'N 89°16.226'E			Silty Clay Loam	
		3	25°39.619'N 89°15.397'E			Silty Clay Loam	
		4	25°38.932'N 89°16.281'E			Loam	
		5	25°39.483'N 89°16.407'E			Loam	
	Kaonia	6	25°44.405'N 89°20.653'E		Kaonia	Silty Loam	
		7	25°45.037'N 89°21.137'E			Silty Loam	
		8	25°45.794'N 89°21.838'E			Silty Loam	
		9	25°45.790'N 89°21.779'E			Loam	
		10	25°45.530'N 89°20.726'E			Loam	
	Gongachara	11	25°51.083'N 89°13.827'E		Gongachara	Loam	
		12	25°50.277'N 89°14.324'E			Loam	
		13	25°50.017'N 89°14.238'E			Loam	
		14	25°50.108'N 89°13.705'E			Silty Loam	
		15	25°50.531'N 89°13.600'E			Loam	

App. Table 2: Some basic information of soil samples collected from different farmers field of Bhanga, Faridpur T.Aman 2017

AEZ No.	Location	Sample No. (0-15 cm)	GPS Reading	Land Type	Soil Series	Soil Textural Class	Land Use
12	Bhanga, Faridpur	1	23°24.146'N 89°56.907'E		Sara, Gopalpur, Gongar, Ishurdi, Batra	Silty Clay	Wheat-Jute-T.Aman Kalojira-Jute-T.Aman Onion-Jute-B.Aman
		2	23°24.066'N 89°56.917'E			Clay	
		3	23°24.358'N 89°57.012'E			Silty Clay	
		4	23°24.497'N 89°57.108'E			Clay	
		5	23°24.452'N 89°57.154'E			Clay	
		6	23°24.587'N 89°57.365'E			Clay	
		7	23°24.669'N 89°57.508'E			Clay	
		8	23°24.822'N 89°57.592'E			Clay	
		9	23°24.870'N 89°57.605'E			Clay	
		10	23°23.313'N 89°59.350'E			Clay	

App. Table 3: Some basic information of soil samples collected from different farmers field of Habiganj, T.Aman 2017

AEZ No.	Location	Sample No. (0-15 cm)	GPS Reading	Land Type	Soil Series	Soil Textural Class	Land Use
21	Chunarogat	1	24°13′56.45′′N 91°30′12.38′′E		Bahubal, Borolekha, Pritimpasa	Silty Clay	Boro-Fallow-T.Aman
		2	24°14′49.06′′N 91°29′49.53′′E			Silty Clay	
		3	24°15′57.65′′N 91°28′42.08′′E			Silty Clay Loam	
		4	24°15′85.05′′N 91°28′49.28′′E			Silty Clay Loam	
		5	24°16′07.15′′N 91°27′23.42′′E			Silty Clay Loam	
	Habigang sadar	1	24°16′06.99′′N 91°27′5.06′′E		Pritimpasa, manu	Silty Clay Loam	
		2	24°16′07.02′′N 91°27′5.52′′E			Loam	
		3	24°16′20.50′′N 91°23′45.56′′E			Clay Loam	
		4	24°17′32.15′′N 91°27′5.52′′E			Clay Loam	
		5	24°16′07.02′′N 91°27′26.58′′E			Clay Loam	
	Madhubpur	1	24°12′57.098′′N 91°21′37.30′′E		Bahubal, manu	Clay	
		2	24°12′27.28′′N 91°21′14.26′′E			Silty Clay Loam	
		3	24°11′42.56′′N 91°21′03.04′′E			Silty Clay Loam	
		4	24°11′48.06′′N 91°20′46.14′′E			Silty Clay Loam	
		5	24°10′05.27′′N 91°20′82.61′′E			Silty Clay Loam	

App. Table 4: Some basic information of soil samples collected from different farmers field of Gazipur, T.Aman 2017

AEZ No.	Location	Sample No. (0-15 cm)	GPS Reading	Land Type	Soil Series	Soil Textural Class	Land Use
28	Kapasia	1	24°2.166'N 90°32.250'E	Medium high land	Salna Noyadda Tejgaon Khilgaon Kolma	Silty Clay loam	Boro-Fallow-T.Aman Fallow-Fallow-T.Aman
		2	24°2.106'N 90°32.510'E			Silty Clay loam	
		3	24°3.251'N 90°32.475'E			Silty loam	
		4	24°10.151'N 90°35.515'E			Silty Clay	
		5	24°11.354'N 90°36.230'E			Silty Clay	
	Sripur	6	24°7.280'N 90°30.158'E			Silty Clay loam	
		7	24°18.151'N 90°44.207'E			Silty loam	
		8	24°17.949'N 90°44.277'E			Silty loam	
		9	24°17.151'N 90°44.207'E			Silty loam	
		10	24°17.912'N 90°44.378'E			Silty loam	
	Gazipur Sadar	11	23°58.680'N 90°24.415'E			Silty Clay loam	
		12	23°58.450'N 90°24.115'E			Silty Clay	
		13	23°57.395'N 90°24.108'E			Silty Clay	
		14	23°59.340'N 90°24.108'E			Silty Clay loam	
		15	23°59.358'N 90°24.480'E			Silty Clay loam	

App. Table 5: Some basic information of soil samples collected from different farmers' field of Rangpur, Boro 2017-18

AEZ No.	Location	Sample No. (0-15 cm)	GPS Reading	Land Type	Soil Series	Soil Textural Class	Land Use
03	Mithapukur	1	25°38.275'N 89°16.564'E	Medium high land	Polashbari	Silty Loam	Boro-Fallow-T.Aman Potato-Boro-T.Aman Maize-T.Aus-T.aman Potato-Maize-T.Aman Tobacco-Fallow-T.Aman Vegetable-Jute-T.Aman
		2	25°38.300'N 89°16.492'E			Silty Clay Loam	
		3	25°39.405'N 89°16.349'E			Silty Loam	
		4	25°39.361'N 89°16.481'E			Silty Clay Loam	
		5	25°40.081'N 89°16.339'E			Silty Clay Loam	
		6	25°40.029'N 89°16.526'E			Loam	
		7	25°37.809'N 89°16.177'E			Loam	
	Pirgong	8	25°30.122'N 89°17.371'E		Polashbari	Silty Clay Loam	
		9	25°30.096'N 89°17.420'E			Silty Loam	
		10	25°29.858'N 89°17.440'E			Silty Loam	
		11	25°29.834'N 89°17.433'E			Silty Loam	
	Kaonia	12	25°47.901'N 89°21.028'E		Kaonia	Loam	
		13	25°41.468'N 89°21.363'E			Silty Loam	
		14	25°46.448'N 89°21.265'E			Silty Loam	
		15	25°46.189'N 89°21.147'E			Silty Loam	
	Go ngachara	16	25°50.038'N 89°13.392'E		Gongachara	Silty Loam	
		17	25°50.760'N 89°13.097'E			Silty Loam	
		18	25°51.627'N 89°13.967'E			Silty Loam	
		19	25°51.753'N 89°14.437'E			Loam	
		20	25°50.703'N 89°14.629'E			Loam	
		21	25°50.283'N			Silty Loam	

			89°15.933'E				
	Rangpur sadar	22	25°46.667'N 89°14.057'E		Polashbari	Sandy Clay	
		23	25°47.150'N 89°14.004'E			Loam	
		24	25°47.560'N 89°14.011'E			Silty Loam	
		25	25°48.352'N 89°14.241'E			Silty Loam	

App. Table 6: Some basic information of soil samples collected from different farmers' field of Bhanga, Faridpur, Boro 2017-18

AEZ No.	Location	Sample No. (0-15 cm)	GPS Reading	Land Type	Soil Series	Land Use
12	Bhanga, Faridpur	1	23°23.362'N 89°59.456'E	Low land	Sara, Gopalpur, Gongar, Ishurdi, Batra	Boro-Fallow-Fallow
		2	23°23.398'N 89°59.474'E			
		3	23°23.425'N 89°59.487'E			
		4	23°23.340'N 89°59.473'E			
		5	23°23.386'N 89°59.528'E			
		6	23°22.930'N 90°0.129'E			
		7	23°22.930'N 90°0.129'E			
		8	23°22.891'N 90°0.102'E			
		9	23°22.830'N 90°0.109'E			
		10	23°22.791'N 90°0.142'E			
		11	23°22.705'N 90°0.099'E			
		12	23°22.680'N 90°0.081'E			
		13	23°22.589'N 90°0.045'E			
		14	23°22.530'N 90°0.005'E			
		15	23°22.458'N 90°0.105'E			
		16	23°23.565'N 89°59.257'E			
		17	23°23.840'N 89°59.190'E			
		18	23°23.860'N 89°59.198'E			
		19	23°23.709'N 89°59.239'E			
		20	23°23.721'N 89°59.220'E			
		21	23°23.532'N 89°59.255'E			

		22	23°23.700'N 89°59.240'E			
		23	23°23.708'N 89°59.249'E			
		24	23°23.872'N 89°59.183'E			
		25	23°23.861'N 89°59.203'E			

App. Table 7: Some basic information of soil samples collected from different farmers field of Habiganj, Boro 2017

AEZ No.	Location	Sample No. (0-15 cm)	GPS Reading	Land Type	Soil Series	Soil Textural Class	Land Use
21	Habigang sadar	1	24°24.'873''N 91°25'579''E		Bejura, Richi, Fagu, Hakaloki	Clay Loam	Boro-Fallow-Fallow
		2	24°24.'880''N 91°25'570''E			Sandy Clay Loam	
		3	24°24.'885''N 91°25'568''E			Clay	
		4	24°24.'891''N 91°25'566''E			Sandy Clay	
		5	24°24.'895''N 91°25'562''E			Clay	
		6	24°24.'326''N 91°25'313''E			Loam	
		7	24°24.'310''N 91°25'301''E			Sandy Loam	
		8	24°24.'290''N 91°25'300''E			Sandy Clay Loam	
		9	24°24.'283''N 91°25'291''E			Sandy Clay	
		10	24°24.'276''N 91°25'275''E			Sandy Clay	
	Baniyachong	11	24°25.'860''N 91°23'752''E		Salla, Ajmirigang, Guangut	Sandy Clay Loam	
		12	24°25.'902''N 91°23'615''E			Sandy Clay Loam	
		13	24°26.'150''N 91°23'152''E			Sandy Clay Loam	
		14	24°26.'807''N 91°22'961''E			Sandy Clay Loam	
		15	24°27.'521''N 91°22'230''E			Clay Loam	
		16	24°28.'384''N 91°22'281''E			Loam	
		17	24°28.'514''N 91°22'511''E			Loam	
		18	24°31.'865''N 91°23'401''E			Silty Loam	
		19	24°32.'112''N 91°23'975''E			Clay	
		20	24°32.'565''N 91°23'990''E				

	Nabigang	21	24°33.’112’’N 91°28’419’’E		Fagu, Modhunagar, Terchibari	Clay	
		22	24°31.’145’’N 91°29’663’’E			Silty Clay Loam	
		23	24°31.’503’’N 91°29’805’’E			Silty Clay Loam	
		24	24°31.’690’’N 91°29’928’’E			Silty Clay Loam	
		25	24°31.’985’’N 91°29’991’’E			Silty Clay Loam	

App. Table 8: Some basic information of soil samples collected from different farmers field of Gazipur, Boro 2017

AEZ No.	Location	Sample No. (0-15 cm)	GPS Reading	Land Type	Soil Series	Soil Textural Class	Land Use
28	Sripur	1	24°6.106'N 90°25.221'E	Medium high land	Salna Tejgaon Khilgaon Kolma	Silty Clay	Boro-T.Aus-T.Aman
		2	24°6.093'N 90°28.343'E			Silty Clay Loam	Boro-Fallow-T.Aman
		3	24°7.293'N 90°30.158'E			Silty Clay Loam	Fallow-Fallow-T.Aman
		4	24°7.760'N 90°30.106'E			Silty Clay Loam	Boro-Fallow-Fallow
	Kapasia	5	24°3.291'N 90°32.260'E			Silty Clay Loam	
		6	24°8.316'N 90°34.596'E			Silty Clay	
		7	24°9.324'N 90°35.029'E			Silty Clay Loam	
		8	24°10.141'N 90°35.537'E			Silty Clay	
		9	24°11.172'N 90°36.174'E			Clay	
		10	24°6.016'N 90°33.916'E			Silty Clay	
		11	24°5.458'N 90°34.018'E			Silty Clay Loam	
		12	24°4.828'N 90°33.877'E			Silty Clay Loam	
		13	24°4.571'N 90°33.785'E			Silty Clay	
		14	24°4.229'N 90°33.609'E			Silty Clay Loam	
	Gazipur Sadar	15	23°58.712'N 90°24.309'E			Silty Clay Loam	
		16	23°58.387'N 90°24.181'E			Silty Clay Loam	
		17	23°57.812'N 90°24.000'E			Silty Clay Loam	
		18	23°57.764'N 90°24.832'E			Silty Loam	
		19	23°57.163'N 90°24.910'E			Silty Loam	
		20	23°56.841'N 90°25.531'E			Silty Loam	
		21	23°56.800'N 90°27.599'E			Silty Loam	

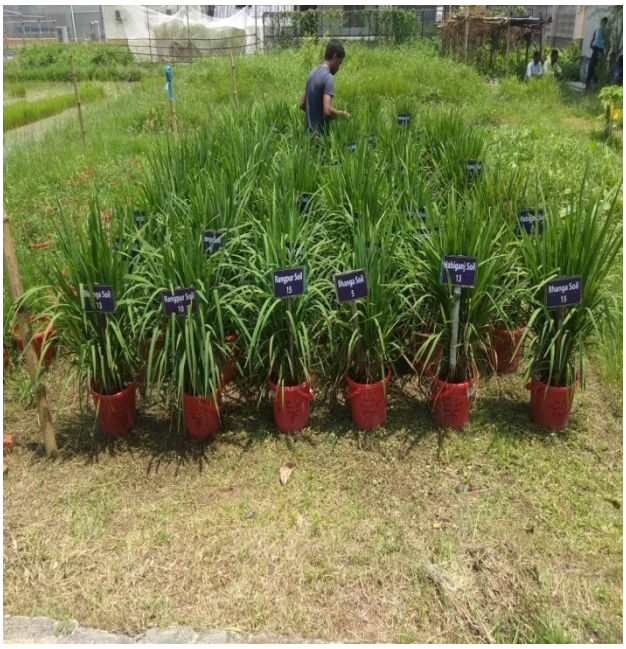
		22	23°59.378'N 90°24.005'E			Clay Loam	
		23	23°59.498'N 90°24.178'E			Silty Loam	
		24	23°59.613'N 90°24.507'E			Silty Loam	
		25	23°59.354'N 90°24.477'E			Silty Loam	

Some Picture

Soil collection for laboratory analysis and pot experimentation from different location

Soil preparation for laboratory analysis and pot experimentation from different location

Pot experimentation in T.Aman 2017 season, BRRI-Gazipur



Experiment set up in Boro 2017-18 season, BRRI-Gazipur

Field visit with divisional scientists, Boro-2017-18