Project ID 707

Competitive Research Grant

Sub-Project Completion Report

on

Up-scaling of biofertilizer for improvement of soil health and rice yield in Bangladesh

Project Duration

May 2016 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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Bangladesh.

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Acronyms

As	Arsenic
B	*Bacillus*
BF	Biofertilizer
Cd	Cadmium
Cfu	Colony forming unit
Cr	Chromium
Cu	cupper
ha	hectare
IAA	Indoleacetic acid
K	Potassium
l	Litter
N	Nitrogen
NFB	Free living N_2 fixing bacteria
OC	Organic carbon
P	Phosphorus
Pb	Lead
pp	Procurement plan
ppm	Parts per million
PSB	Phosphate Solubilizing Bacteria
R/S	Regional Station
S	Sulfur
t	Tone
TSP	Triple Super Phosphate
Zn	Zinc

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Executive Summary

Modern agriculture highly relies on chemical fertilizer. Long-term use of chemical fertilizer impairs soil biology and causes environment pollution. Loss of soil health is directly related to crop production. Breaking rice yield ceiling needs healthy and productive soil. In this context, to restore soil biology and improve rice yield, BRRI soil science division with the support of competitive research grant (CRG), has updated BRRI developed biofertilizer, and named "**Bio-organic fertilizer**". The carrier material of the prepared biofertilizer was combination of vegetable waste/ degradable kitchen waste (80%), rice husk biochar (15%) and rock phosphate (5%). Consortiums of ten (10) plant growth promoting bacteria (PGPB) were added with carrier material. The microorganisms involved were categorized as free-living N_2fixing bacteria, phosphate solubilizing bacteria (PSB) and indoleacetic acid (IAA) producing bacteria. Rock phosphate (5%) was incorporated in this product as an alternate of TSP fertilizer for rice production. Incorporated phosphate solubilizing bacteria were able to ensure bio-available P from rock phosphate during crop growing period. The beneficial bacteria added in this biofertilizer were indigenous and isolated from favorable and unfavorable rice ecosystem (drought, saline and acid soil). Production technology ensured a safe and environment friendly decomposition of kitchen waste/kaccha bazaar vegetable waste to be recycled in the soil. The chemical composition of the developed biofertilizer was tested at the laboratory and found to be safe for the environment. The developed biofertilizer was applied at T. Aman rice grown in 2017 at BRRI farm Gazipur, BRRI R/S Rajshahi, BRRI R/S Barisal, and at farmers' fields of Rajshahi, Pirojpur, Kuakata, and Kishoreganj. It was also tested in the research stations and farmers field at Boro rice grown in 2017-18. The results of the research stations and farmers' field proved that application of biofertilizer @ 2 t ha^{-1} in T. Aman and Boro season fulfilled the requirement of 25-30% urea and eliminate 100% TSP fertilizer requirement for rice production, and gave statistically similar or higher (5 to 20%) grain yield as compared to full (100%) chemical NPK fertilizer depending on soil types. The biofertilizer was suitable for wide range of soil including saline soil (6-8 ds/m). The research result also proved that application of biofertilizer improved soil biology. In a nut shell application of bio-organic fertilizer 2 ton ha^{-1} improved soil biology, rice yield and save 30% urea-N and 100% TSP fertilizer use for rice production in Bangladesh.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Up-scaling of biofertilizer for improvement of soil health and rice yield in Bangladesh
2. **Implementing organization:** Bangladesh Rice Research Institute
3. **Principal Investigator** (Full address with phone and e-mail): Dr. Umme Aminun Naher, Principal Scientific Officer, Soil Science Division, Bangladesh Rice Research Institute, Mobile: 01913151914
   Co-principal investigator (Full address with phone and e-mail): Md. Imran Ullah Sarkar, Scientific Officer, Soil Science Division, Bangladesh Rice Research Institute, Mobile: 01721715998
4. **Sub-project budget** (Tk): 2879000 Tk.
   4.1 Total: 2879000 Tk.
   4.2 Revised (if any): 2879000 Tk.
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:**
7. Rice production in Bangladesh is based on chemical fertilizer and pesticide, which impaired soil quality, ecosystem biodiversity and causes environmental pollution. Loses of biodiversity is related to deterioration of soil health as nutrient cycling is directly related to microbial activity. Microorganisms play major roles in nutrient transformation and element cycling and influence the availability of these nutrients for plant uptake. Wetland rice ecosystem can harbor a diverse group of plant growth promoting bacteria (PGPB). PGPB, which efficiently colonize the root endosphere has been shown to fix nitrogen (Hurek *et al.*, 1997). It has been reported that inoculated rice plants can get similar benefit (Chalk, 1991). The transfer of fixed N_2 varied from 1.5 to 21% (Sherestha & Ladha, 1996).There are also strong evidences that soil bacteria are capable of transforming soil P to the forms available to plant. Microorganisms enhance the P availability to plants by mineralizing organic P in soil and by solubilizing precipitated phosphates. The production of hormonal substances by the bacteria can alter root morphology, increase extended surface area and enable plants to absorb more nutrients from the soils. The growth and colonization of the bacteria on plant roots can be influenced by several soil chemical, physical and biological factors. The availability of C, N or P can limit bacterial growth in aquatic systems.The correction of nutrient deficiency in all types of soil is based on short- term management, but if we consider soil health, breaking yield ceiling and sustainable rice production, we need to improve paddy soil biology. It is true that genetic potential of a high yielding variety will express its performance only if the soil is healthy and productive. Unfortunately, yield is plateau even with so many improved rice varieties. However, not much work has been reported to improve soil health by restoring biological properties of paddy soil for breaking yield ceiling. In this context, BRRI has developed a biofertilizer with combination of vegetable waste, rice husk biochar and rock phosphate (5%). The beneficial bacteria added in this biofertilizer were isolated from AEZ-28 soil (favorable ecosystem). However, for all types of

soil it needs to add some potential bacteria from stress environment such as saline and drought prone area (unfavorable ecosystem). The developed biofertilizer (1 t ha^{-1}) already tested in Aus rice 2015 and Boro rice in 2016 at BRRI Farm Gazipur. The findings showed that it was able to produce comparable yield with full chemical fertilizer. Moreover, it saved 30% N, and 100% chemical P fertilizer for rice production. Up-scaling of this biofertilizer with some potential bacteria obtained from unfavorable ecosystems and dissemination of this biofertilizer may improve rice soil biology and rice yield all over the country.

8. **Sub-project goal:** Improvement of paddy soil biology and rice yield

9. **Sub-project objective (s):**

   i) to identify beneficial rice associated bacteria from selected saline and drought prone paddy soils

   ii) to upscale biofertilizer with beneficial microorganisms and its assessment for the improvement of soil health and paddy yield.

10. **Implementing location (s):** Gazipur, Rajshahi, Barisal

11. **Methodology:**The study was comprised of two steps to fulfill the objectives of the project - in the first phase potential bacteria were isolated and characterized for the improvement of existing biofertilizer. In second phase, biofertilizer was tested in research station and applied to the farmer's field (farmer's participation).

Improvement of biofertilizer

The study was done for isolation and characterization of plant growth promoting bacteria from different rice soils of Bangladesh to improve the existing BRRI developed biofertilizer.

Experiment 1: Isolation and characterization of free living N_2 fixing and phosphate solubilizing bacteria

Specific objectives:

i) To isolate and bio-molecular characterize the free-living N_2 fixing and phosphate solubilizing bacteria from favorable and un-favorable rice ecosystem

ii) To improve biofertilizer prepared with potential bacterial strains

Soil sample collection:

Soil samples were collected from 10 locations of each Gazipur (AEZ 28), Rajshahi (AEZ 11), Lalmonirhat (AEZ 2), Srimongol (AEZ 20), Barisal, and Kuakata (AEZ 13), for isolation of free living N_2 fixing and phosphate solubilizing bacteria. Soils were collected from rice field (0-15 cm depth) and preserved in 4^{o}C temperature until analysis. Soil samples were collected randomly and replicated four times for analyses of each property.

Soil chemical properties: Soil properties such as soil reaction, soil organic matter, total macro and micro nutrient contents were determined following methods provided in Fertilizer Recommendation Guide, 2012.

Soil biological properties

Culturable total bacteria, fungus and actinomycetes population were determined in Nutrient Agar, King's B agar, Potato dextrose agar, Actinomycetes agar, and Anaerobic agar plate. Total population was enumerated following 'total plate count method'. In brief, approximately 10 g soil sample was added into 95 ml sterile distilled water and shacked in a mechanical shaker for 10 minute. About one ml of solution was added with nine ml sterile distilled water and a series of dilution were prepared up to 10^{10} dilution. Exactly 0.1 ml of solution from each dilution was spread on respected media plate and incubated for 3 days at 28^oC temperature. Total population was counted and expressed as Cfu g^{-1} soil dry weight.

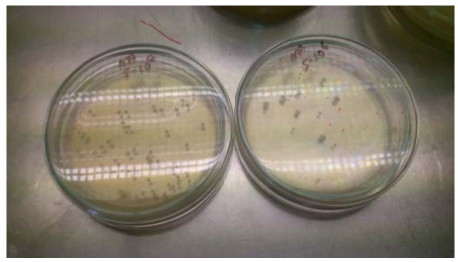


Plate: Total population count in Nutrient Agar medium

Isolation of Free-living N_2 fixing bacteria: Free living N_2 fixing bacteria were isolated from selected paddy soils of different AEZ's in N-free media according to the protocol of Naher et al (2009).The population was counted after 3 days of incubation following 'Total plate count method'. The media composition was (g/l): 5 g Malic acid, 0.5 g K_2HPO_4, 0.2 g $MgSO_4$. 7 H_2O, 0.1 g NaCl, 0.02 g $CaCl_2$ and 0.5% bromothymol blue in 0.2 N KOH (2 ml), 1.64% Fe-EDTA solution (4 ml), and 20 g agar (pH 7.2).

Plate: Free living N_2fixing bacteria grown in N-Free medium

Isolation of phosphate solubilizing bacteria (PSB): Phosphate solubilizing bacteria were isolated in Pikovskaya media plate according to Panhwar et al (2012). The media inoculated with the isolates were incubated for 3 days and observed for the formation of yellow zone around the colony due to the utilization of tricalcium phosphate present in the medium. Media composition was (g/l) glucose 10, tri-calcium phosphate 5, ammonium sulphate 0.5, sodium chloride 0.2, magnesium sulphateheptahydrate 0.1, potassium chloride 0.2, ferrous sulfate heptahydrate 0.002, manganese (II) sulfate dehydrate 0.002, bromophenol blue (2.4 mg/ml), agar 20, and finally adjusted at pH 7.0.

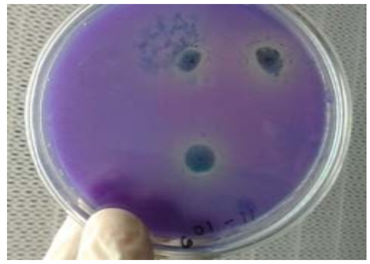


Plate: Phosphate solubilizing bacteria grown in Pikovskaya medium

Determination of N_2 fixing activity by production of ammonia: Total N was determined from broth culture following distillation method. The isolated strains that were capable to grow only on N-free medium were cultured in N_2 free broth without adding bromothymol blue at 30°C for 7 days on a rotary shaker (120 rpm). The bacteria culture was then centrifuged 4000 × g for 5 minutes and filtered through 0.22µm filter paper. The filtrate was used to determine total N by distillation method (Naher et al. 2012).

Determination of P solubilizing activity: P solubilizing activity was determined in National Botanical Research Institute's Phosphate growth medium (NBRIP) broth culture following Nautiyal, (1999); Mehta and Nautiyal (2001). The isolated bacterial strains were cultured in NBRIP broth containing tri-calcium phosphate (TCP) for 5 days. Exactly, 2 ml of samples were taken for P determination. The samples were first allowed to sediment for 15 minutes and were then centrifuged at 4000 × g for 5 minutes. The supernatant was filtered through 0.22 µm filter paper and kept at -20^0C until analysis. The available P was determined using the procedure described by Murphy and Riley (1962).

Plate: P solubilizing activity determination in broth culture

Determination of indoleacetic acid (IAA) production: Isolates were inoculated in nutrient broth with addition of tryptophan (2 mg ml^{-1}) and incubated at 28 ± 2^oC for 3 days. The culture was centrifuged at 7000 rpm for 7 min and 1 ml of the supernatant was mixed with 2 ml of Salkowsky's reagent. The IAA concentration was determined by using spectrophotometer at 535 nm.

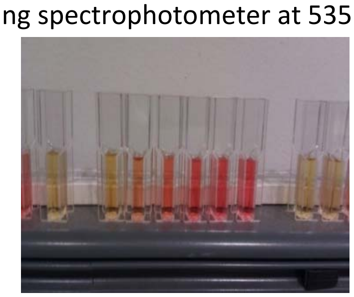


Plate: Indoleacetic acid (IAA) production by the bacteria

Identification of bacteria: Potential bacteria were identified using molecular techniques (16S rRNA gene amplification and sequencing using appropriate primers). Pure culture was send to National Institute of Biotechnology for identification of strain (s). The following primers were used to identify respective bacteria:

Typesof Strain	Primer	
	Forward primer	Reverse primer
PSB	5-AGA GTT TGA TCC TGG CTC AG-3	3- ACG GCT ACC TTG TTA CGA CTT-5
N_2 - fixing	8 F, 5'-AGA GTT TGA TCC TGG CTC AG-3'	1492R, 5'-GGT TAC CTT ACG ACT T-3'

Formulation of biofertilizer

Biofertilizer was prepared from a consortium of locally isolated 10 bacteria and organic carrier material (bio-degradable kitchen waste). Rock phosphate (5%) was incorporated in this product, which act as an alternate of TSP fertilizer for rice production. The microorganisms involved in this biofertilizer were grouped as free-living N_2 fixing bacteria, PSB and IAA producing bacteria. Organic residues added were vegetable and kitchen wastes (80%), and 15% biochar of chitadhan. About 3.0 ton of biofertilizer was prepared toexecute 12 farmers' field demonstrations and three research station's experiments.

Diagram : Formulation of Biofertilizer

Design of experiments and methods of data analyses: Data generated from soil physical, chemical and biological properties were analyzed for ANOVA following completely randomized design (CRD) and means of replicated samples were separated using DMRT statistical tool.

Evaluation of biofertilizer in the research stations:

In the second step prepared biofertilizer was applied to the research stations (Gazipur, Barisal and Rajshahi) and farmers field of Kisorgonj, Rajshahi, Patuakhali, Borguna, Dakope and Kuakata. For research station, following experiment were conducted;

Experiment: Effect of biofertilizer on rice yield and soil biology

Specific objectives:

i) to evaluate efficacy of biofertilizer to promote rice plant growth and yield and to find appropriate dose of chemical fertilizer

iii) to improve soil biology

Treatments:

Location: BRRI, Gazipur

T_1 = Control, T_2 = NPKS, T_3 = 100% NKS, T_4 = Biofertilizer @ 2 t ha^{-1} + 100% NKS,

T_5 = 75% NPKS, T_6 = Biofertilizer @ 2 t ha^{-1} + 75% NKS, T_7 = Biofertilizer @ 2 t ha^{-1} + 75% NKS, T_8 = Biofertilizer @ 2 t ha^{-1}

Locations: BRRI Barisal R/S, and Rajshahi R/S

T_1 = Biofertilizer @ 2 t ha^{-1} T_2 = NPKS, T_3 = Biofertilizer @ 2 t ha^{-1} + 75% NKS, T_4 = Control.

Design of the experiment:

Randomized complete block design (RCBD) with 3 replications.

Data collection: Indicators of plant growth promotion such as plant height, tiller number, panicle number, filled grain, grain and straw yield were recorded. Soil samples were collected after harvesting crop. Soil chemical and biological properties were recorded.

Demonstration of biofertilizer in the farmer's field (Application of technology):

Prepared biofertilizer was evaluated in the farmer's field of Rajshahi, Barishal and Kishoreganj. Farmer's field was surveyed and demonstration was set up with the farmer's participation in T. Amanin 2017. A number of four farmers were selected from each location.

Treatments: T_1=BF + NKS (70%), $T_{2=}$ Farmers' practice

Data Collection: Indicators of plant growth promotion such as plant height, tiller number, panicle number, filled grain, grain and straw yield were recorded. Soil samples were collected before and after harvesting crop. Soil chemical and biological properties were recorded.

Farmers' opinion/ impact study: Questionnaire form was prepared about biofertilizer and data was collected from all locations for farmer's opinion about the biofertilizer.

12. **Results and discussion:**

All the experiments were conducted to achieve the objectives of the sub project. The results are described below as per subproject objectives in this section

Isolation and characterization of free living N_2 fixing and phosphate solubilizing bacteria

To enrich biofertilizer with potential strains from favorable and unfavorable ecosystem a total number of 50 soil samples were collected from Lalmonirhat, Patuakhali and Gazipur soil. Twenty five strains were isolated and selected for N_2 fixing, phosphate solubilizing and indoleacetic acid production. Isolated strains were capable of fixing N_2 and solubilizing insoluble P (Table 1). The N_2 fixing ability of the isolated strains was varied from 100 to 1600 ppm. The highest N_2 fixation was found in SL1, strain isolated from Lalmonirhat followed by SG4. Phosphate solubilizing ability was varied from 300-1300 ppm. The highest P solubilizing activity was found in SL5, strain isolated from Lalmonirhat soil. It is known that indoleacetic acid (IAA) booster plant root growth (Biswas et al., 2000; Naher et al., 2015). Extensive root architecture is able to capture nutrient from distant soil area and increased plant growth and development (Glick, 2005). Isolated bacteria were tested for IAA production in the presence of tryptophan and found that the highest IAA (0.28%)was produced by the strain S29, isolated from Patuakhali soil (Fig. 1a).Strains isolated from Gazipur soil produced 110 to 500 ppm IAA (Fig. 1b).

Table 1. N_2- fixing and Phosphate solubilizing capacity of isolated strains from Gazipur, Patuakhali, Lalmonirhat, and KomolganjSreemongolsoil.

Strains	P(ppm)	N(ppm)	**N-free media	*PSB media
SG1	600	700	+	+
SG2	1000	300	+	+
SG3	800	400	+	+
SG4	1200	800	+	+
SG5	700	400	+	+
SG6	800	300	+	+
SG7	600	800	+	+
SG8	600	400	+	+
SG9	400	300	+	+
SG10	600	600	+	+
SG11	1000	700	+	+
SG12	700	300	+	+
SG13	700	300	+	+
SG14	800	700	+	+
SG15	100	300	+	+
SP29	800	700	+	+
SP30	100	300	+	+
SL1	1600	500	+	+
SL2	400	700	+	+
SL3	100	1200	+	+
SL4	1100	800	+	+
SL5	100	1300	+	+
SL6	200	700	+	+
SL7	600	800	+	+
SL8	1000	600	+	+
SK1	100	800		

*Phosphate solubilizing bacteria, **N_2 fixing bacteria, SG1-SG15 denotes strains isolated from Gazipur soil, SP29-SP30 denotes strains isolated from Patuakhali (saline soil), SL1-SL8 denotes strains isolated from Lalmonirhat (acid soil). SK1, strain isolated from Komolganj, Sreemongol (acid soil).

Identification of potential strain and its special features

Among the isolated strains, seven (7) potential strains were selected for molecular identification (16S rRNA gene amplification and sequencing using appropriate primers) based on their N_2 fixation, phosphate solubilization and indoleacetic acid production capabilities. Pure isolates were sent to Institute of Bioscience for identification. The strain identification with location is given in Table 2 and scientific classification is given in Table 3a & b. The DNA sequencing of the strains is given in the appendix-1.

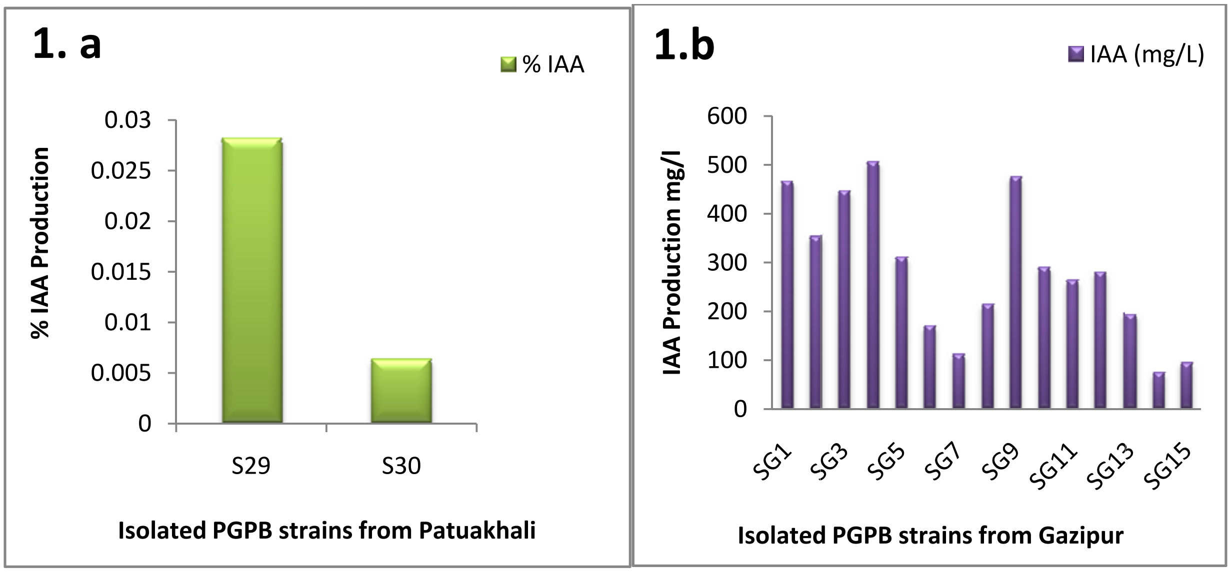


Figure 1a & b: IAA producing ability of the bacteria strains isolated from favorable and unfavorable ecosystem

Table 2: Identification of the potential (PGPB) strains from different location

Strain ID	***Strain***	**% *similarity**
SL2 (Lalmonirhat)	*Bacillus mycoides*	97
SL3 (Lalmonirhat)	*Proteus sp*	100
SK1 (Komolgonj)	*B cereus*	95
SG16 (Gazipur)	*B subtilis*	97
SL4 (Lalmonirhat)	*B pumilus*	97
SP1 (Patuakhali)	*Paenibacillussp*	97
SG11 (Gazipur)	*Paenibacilluspolymyxa*	94

*NCBI Blast Nucleotide Sequence

Bacillus mycoides: *Bacillus mycoides* isolated from Lalmonirhat soil. *B. mycoides* is an ammonifying bacterium, and can convert peptone (protein, organic N) into NH_3. This strain was able to solubilize phosphate and produce IAA. In water, NH_3 becomes NH_4. *B. mycoides* found in common pesticides and are used to inhibit the growth of harmful bacteria and fungi. There seems to be no negative effects on humans or the environment.

Proteus sp: It was isolated from Lalmonirhat soil. It is high N_2 fixing (0.13%) bacteria, it produces indoleacetic acid. This strain produces urease enzyme.

Paenibacilluspolymyxa: *Paenibacilluspolymyxa* was isolated from Gazipur soil. It is known as phosphate solubilizing bacteria. It can fix N_2 and produces IAA. These bacteria are used as bio-pesticide. It has major role in formation of soil aggregate as it produces exopolysaccharides.

Bacillus cereus: It is a N_2 fixing (0.36%), phosphate solubilizing (0.11%), urease and IAA producing bacteria. It was isolated from Lalmonirhat.

Bacillus subtilis: *Bacillus subtilis* was isolated from acid soil of Komolganj, Sreemongol. It is phosphate solubilizing, N_2 fixing, IAA and exopolysaccharides producing bacteria. Exoplysaccharide producing bacteria have role in formation of soil aggregates. This PGPB is also used as a fungicide.

Bacillus pumilus: *Bacillus pumilus*was isolated from saline soil of Patuakhali. It is IAA producing, N_2 fixing and phosphate solubilizing bacteria, it is also capable to produce exopolysaccharide. This PGPB isused as fungicide.

***Bacillus* sp.** Isolated from red terrace soil of Gazipur. This strain produces high amount of IAA (0.40%) and fixes 0.14% of N. Among the isolated bacteria it is the most potential bacteria.

Table 3a.Scientific classification of the isolated strains

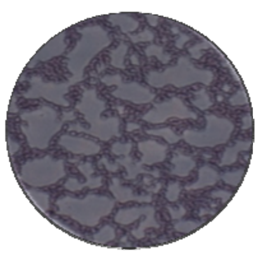
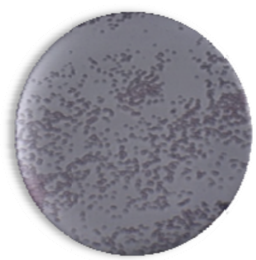
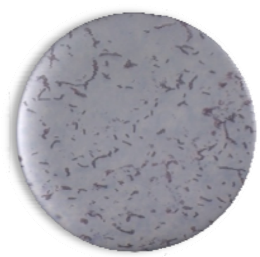
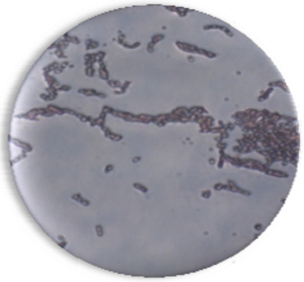
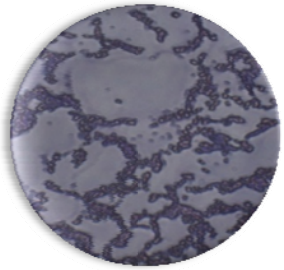
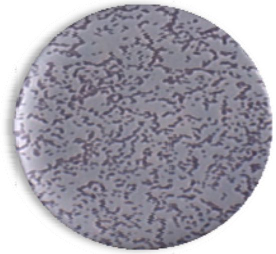
Kingdom: Bacteria			
Division:	Firmicutes	Bacteria	Firmicutes
Class:	Bacilli	Proteobacteria	Bacilli
Order:	Bacillales	Gammaproteobacteria	Bacillales
Family:	Bacillaceae	Enterobacteriales	Paenibacillaceae
Genus:	Bacillus	Morganellaceae	*Paenibacillus*
Species:	*mycoides*	Proteus	*polymyxa*
	 ***Bacillus mycoides***	 ***Proteus sp***	 ***Paenibacilluspolymyxa***

Table 3b.Scientific classification of the isolated strains

Kingdom: Bacteria			
Division:	Firmicutes	Firmicutes	Firmicutes
Class:	Bacilli	Bacilli	Bacilli
Order:	Bacillales	Bacillales	Bacillales
Family:	Bacillaceae	Bacillaceae	Bacillaceae
Genus:	Bacillus	Bacillus	Bacillus
Species:	*B. cereus*	*B. subtilis*	*B. subtilis*

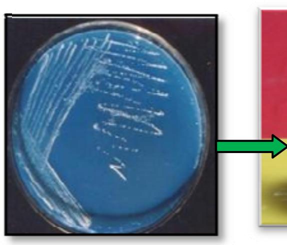
	 ***Bacillus cereus***	 ***Bacillus subtilis***	 ***Bacillus pumilus***

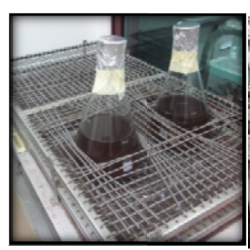
Production of Biofertilizer

Biofertilizer was prepared from a consortium of locally isolated 10 bacteria, among them seven were molecularly identified and rests of the 3 were identified by morphological characteristics as *Bacillus*. The microorganisms involved in this bio-organic fertilizer are grouped as free-living N_2 fixing bacteria, PSB and IAA producing bacteria. Organic carrier materials (kitchen wastes), rock phosphate (5%), and 15% biochar of chitadhan were incorporated in this biofertilizer. Added rock phosphate acted as an alternate of TSP fertilizer for rice production. Carrier materials were added in a closed chamber and kept for 3 months to be rotten. Bacteria inoculumn was prepared in 2.5% molasses solution and added in the rotten carrier material. Mixed carrier material and the inoculum were kept for 1 month until it become dry. This biofertilizer can be applied at 40-50% moisture. But for preservation 20% moisture is the best. The biofertilizer is easy to prepare, user friendly and reduce environment pollution as properly waste management policy followed.




Plates: Vegetable or kitchen waste Rock Phosphate Rice husk biochar




Plates: PSB NFB 2.5% Molasses incubation Prepared biofertilizer

The chemical composition of prepared biofertilizer is given in Table 4.

Special features of the biofertilizer (Biofertilizer): Biofertilizer reduced

1. About 25-30% urea fertilizer use in rice production
2. 100% TSP fertilizer use
3. Add C to the soil as15% Biochar added
4. Improve soil biology with beneficial soil bacteria
5. Environment friendly and easy to prepare

Table 4. Composition of Biofertilizer

Parameters	Content
color	Dark grey
Moisture	20%
Physical condition	Non granular
Odor	No foul odor
pH	7.2
OC(%)	25
N (%)	1.4
P (%)	1.04
K (%)	0.91
S (%)	0.35
Zn (%)	0.03
Cu (%)	0.006
Pb (ppm)	0.01
Cd (ppm)	0.67
Cr (ppm)	27.0
As (ppm)	11.50
N_2 fixing Bacteria(cfu g-1)	6×10^8
PSB(cfu g-1)	8×10^8

On research station trial (T. Aman):

BRRI Gazipur:

The experimental plot located at the East block (East-bide) of BRRI farm Gazipur. Soil was clay loam in texture having 1.40% organic carbon, 0.14% total N, 5.65 ppm available P, 0.12 meq /100g soil exchangeable K, and 22 ppm available sulfur. Transplanted Aman rice grown in 2017, eight (8) treatments were used to find out the best chemical fertilizer doses need to be applied with biofertilizer. The highest grain yield was obtained in T_4treatment (BF + NKS 100%) which was statistical similar to the full dose of chemical (T_2) and other reduced chemical fertilizer doses (Table 5). The lowest grain yield was obtained in the fertilizer control treatment. The omission of TSP fertilizer and reduction of chemical fertilizer up to 25% did not reduce grain yield and statistically similar grain yield was recorded with 2 t/ha biofertilizer application and chemical fertilizer applied treatment. Similar trend of straw yield was recorded.

Table 5: Effect of biofertilizer on plant growth and yield at BRRI, Gazipur (variety BRRI dhan71)

Treatment	Tiller m^{-2}	Panicle m^{-2}	Grain Yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	145 b	142 b	3.18 d	3.48 c
T_2	184 a	177 a	3.99 ab	4.37 ab
T_3	171 a	166 ab	3.80 abc	4.05 abc
T_4	188 a	180 a	**4.06 a**	4.63 a
T_5	176 a	171 a	3.73 bc	4.02 abc
T_6	185 a	177 a	3.87 abc	4.36 ab
T_7	183 a	178 a	3.75 abc	4.04 abc
T_8	173 a	169 a	3.57 c	3.69 bc
CV (%)	4.83	5.36	2.97	6.93

T_1=control, T_2= NPKS (100%) **, T_3= NKS (100%), T_4=BF + NKS (100%), T_5= NPKS (75%), T_6= BF+ NKS (75%), T_7= BF*, T_8= Soil inoculation, * BF 2 t ha^{-1}, **NPKS kg/ha@ 67-10-41-10
Date of seeding: 20/6/2017, Date of transplanting: 27/7/17, Date of harvest: 26/10/17

Effect of biofertilizer application on plant nutrient uptake

Biofertlizer supplemented abundant nutrient to the plant. The nutrient uptake in the grain and straw proved that there was no hidden hunger, although 25% less chemical NPK fertilizer was applied. The analytical data also proved that applied rock phosphate in biofertilizer was sufficient to replace 100% TSP fertilizer. In the plant, the highest Nuptake was recorded in T_6(83.49 kg/ha) and it was statistically similar to $T_{4,}$ T_3 andT_2 treatments which proved that biofertilizer was able to supplement 25% N in rice production (Table 6). In case of P and K uptake similar trend was observed. Nutrient uptake in straw also proved that there was sufficient amount of available nutrient in the biofertilizer applied treatment. The significantly high amount of total N uptake was recorded in T_6 and T_4 treatment which proved the contribution of biological fixed N_2 in these treatments. P uptake also proved 5% rock phosphate was adequate for rice production.

Table 6. Effect of biofertilizer application on nutrient uptake in BRRI BRRI dhan71 at Gazipur

Treat	Nutrient Uptake (kg/ha)						Total Nutrient Uptake (kg/ha)		
	Grain			Straw					
	N	P	K	N	P	K	N	P	K
T_1	35.3 c	8.11 d	6.59c	21.87b	3.55 d	45.17 b	57.12 c	11.66 d	51.76 c
T_2	51.7 a	11.81ab	9.59ab	30.59ab	5.35 a	76.62 a	82.28 b	17.17 a	86.22 a
T_3	47.8ab	11.25abc	7.85abc	30.44ab	4.44 bc	61.72 ab	78.26 b	15.7 abc	69.56 abc
T_4	55.81a	12.43 a	10.18a	31.33ab	5.20 ab	75.83 a	87.15 a	17.63 a	86.01 a
T_5	41.7bc	9.50 cd	8.91abc	27.19ab	3.95 cd	56.84 ab	68.9 bc	13.45 cd	65.75 abc
T_6	51.7 a	11.37abc	8.87abc	31.53a	4.95 ab	75.43 a	83.49 a	16.32 ab	84.30 ab
T_7	36.7 c	10.00bcd	7.74bc	25.95ab	4.42 bcd	52.68 ab	62.65 c	14.42 bc	60.4 abc
T_8	34.6 c	8.00 d	6.62c	22.29ab	3.63 cd	48.15 ab	56.95 c	11.64 d	54.77 bc
CV (%)	6.52	6.76	10.05	11.91	6.78	16.99	6.45	5.3	15.21

T_1=control, T_2= NPKS (100%) **, T_3= NKS (100%), T_4=BF + NKS (100%), T_5= NPKS(75%), T_6= BF+ NKS (75%), T_7= BF*, T_8= Soil inoculation, * BF 2 t/ha, **NPKS kg/ha@ 67-10-41-10.

BRRI R/S Rajshahi

BRRI Rajshahi soil contained 1.04% organic carbon, 0.11% total N, 32.36 ppm available P, 0.11 meq/100 g soil exchangeable K, and 22.50 ppm available sulfur. Four treatments were used in T. Aman season (Table 7).The highest grain yield (**3.94 t/ha)** was obtained in T_3 treatment (BF + NKS, 75%) which was statistically similar to 100% NPKS applied treatment (T_2). However, statistically similar grain yield was also obtained with full dose of chemical fertilizer treatment (T_2) and biofertilizer treatment (T_1). The highest straw yield (5.51 t/ha) was obtained with chemical fertilizer treatment (T_2) and it was statistically similar to biofertilizer treated plot (T_2). Research findings also proved that biofertilizer (T_1) alone produced statistically similar yield with full dose of chemical fertilizer, i.e, in BRRI Rajshahi soil, 2 t/ha biofertilizer was enough to replace chemical fertilizer in T. Aman rice season.

Table 7: Effect of biofertilizer on plant growth and yield at BRRI, R/S Rajshahi (variety BRRI dhan71)

Treatment	Tiller/m^2	Panicle/m^2	Grain Yield (t/ha)	Straw yield (t/ha)
T_1	178 a	165	3.40 b	5.30 a
T_2	176 a	173	3.61 ab	5.51 a
T_3	182 a	171	**3.94 a**	4.54 b
T_4	150 b	144	1.90 c	4.07 b
CV (%)	6.37	7.62	7.15	6.31

T_1=BF (2 t ha^{-1}), T_2= NPKS (100%)*, T_3= BF+ NKS (75%), T_4= Control, *NPKS kg t ha^{-1}@ 67-10-41-10

Date of seeding: 7/7/17, Date of transplanting: 20/8/17, Date of harvest: 24/11/17

Effect of biofertilizer application on plant nutrient uptake

Plant nutrient uptake is given in Table 8. In the grain the highest amount of N uptake was observed in T_3 treatment where 25% less urea fertilizer was applied. However in the straw sample the highest amount of N uptake was observed in the biofertilizer applied treatment (T_1). The highest P uptake in grain and straw was found in both T_2 and T_3 treatments which proved rock phosphate was bio available. In the straw sample the highest P uptake was found in T_3 sample. Total N uptake was the highest in the T_3 (BF+ NKS, 75%) followed by T_1 (BF, 2 t/ha) treatment. Total P and K uptake was also high in T_3 treatment.

Table 8: Effect of biofertilizer on plant nutrient uptake at BRRI, R/S Rajshahi (variety BRRI dhan71)

Treat	Nutrient Uptake (kg ha^{-1})						Total Nutrient Uptake (kg ha^{-1})		
	Grain			Straw					
	N	P	K	N	P	K	N	P	K
T_1	54.16b	11.16ab	11.06b	34.81a	4.29b	62.57 b	88.97 ab	15.36b	73.63 b
T_2	50.42c	11.39 a	10.88b	32.22b	4.25b	67.61 ab	81.82 bc	15.64b	78.48 b
T_3	68.18a	12.96 a	14.54a	27.98c	4.88a	71.03 a	96.16 a	17.84a	85.57 a
T_4	49 c	9.20 b	11.45b	25.02d	3.48b	52.64c	75.44 c	12.68c	64.09 c
CV (%)	12.54	9.71	12.92	16	14.68	4.5	6.59	13.08	4.56

T_1=BF (2 t/ha), T_2= NPKS (100%)*, T_3= BF+ NKS (75%), T_4= Control, *NPKS kg/ha@ 67-10-41-10

BRRI R/S Barisal

The soil fertility status of Barisal R/S (Charbodna) was poor, having organic C content of 0.74%, total N, 0.7%, available P, 5.75 ppm, exchangeable K, 0.08 meq/100 g soil and available sulfur12 ppm. Four treatments were used in this study. The highest grain yield (3.94 t/ha) was obtained in BF+ NKS 75% (T_3) which was statistically similar to NPKS 100% (T_2) treatment (Table 9). The lowest grain yield was found in control plot. The highest straw yield was also obtained in T_2 treatment. In Barisal soil only biofertilizer application produced considerable grain yield.

Table 9: Effect of biofertilizer on plant growth and yield at BRRI, R/S Barisal (variety BRRI dhan71)

Treatment	Tiller/m^2	Panicle/m^2	Grain Yield (t/ha)	Straw yield (t/ha)
T_1	178 a	165	3.40 b	5.30 a
T_2	176 a	173	3.61 ab	5.51 a
T_3	182 a	171	**3.94 a**	4.54 b
T_4	150 b	144	1.90 c	4.07 b
CV (%)	6.37	7.62	7.15	6.31

T_1=BF* (2 t/ha), T_2= NPKS (100%) **, T_3= BF+ NKS (75%), T_4= Control, * (2 t/ha), **NPKS kg/ha@ 67-10-41-10.
Date of seeding: 7/7/17, Date of transplanting: 20/8/17, Date of harvest: 24/11/17.

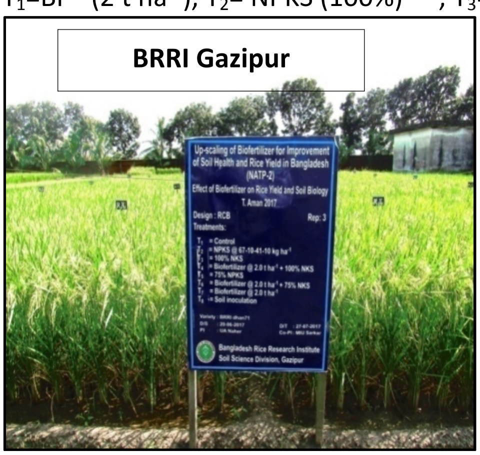
Effect of biofertilizer application on plant nutrient uptake

Nutrient uptake is given in Table 10. The highest amount of grain NPK uptake was found in T_3 (BF+ NKS 75%) treatment. In the straw sample highest amount of N uptake was recorded with chemical fertilizer (T_2) and biofertilizer treatment (T_1). Total N and K uptake was statistically similar in $T_{1,}$ T_2 andT_3treatments.

Table 10: Effect of biofertilizer on plant nutrient uptake at BRRI, R/S Barisal (variety BRRI dhan71)

Treat	Nutrient Uptake (kg ha^{-1})						Total Nutrient Uptake (kg ha^{-1})		
	Grain			Straw					
	N	P	K	N	P	K	N	P	K
T_1	37.28 c	7.76 b	10.66 a	32.72 a	5.79 b	61.32 ab	70.00 a	13.55 b	71.98 a
T_2	41.58 b	8.98 ab	10.80 a	31.52 a	6.68 a	62.29 a	73.09 a	15.65 ab	73.08 a
T_3	48.46 a	11.21 a	12.48 a	20.46 b	6.25 ab	54.14 b	68.92 a	17.47 a	66.62 a
T_4	15.81 d	4.51 c	6.32 b	19.89 b	3.70 c	34.90 c	35.71 b	8.21 c	41.22 b
CV (%)	5.93	9.02	17.68	6.52	6.93	7.36	4.22	10.97	8.44

T_1=BF* (2 t ha^{-1}), T_2= NPKS (100%) **, T_3= BF+ NKS (75%) , T_4= Control, * (2 t ha^{-1}), **NPKS kg ha^{-1}@ 67-10-41-10.


BRRI Gazipur


BRRI R/S Rajshahi

BRRI R/S Barisal

Pictures: Experimental trial at different BRRI Gazipur, BRRI R/S Rajshahi and BRRI R/S Barisal

Demonstration of biofertilizer in the farmer's field (Application of technology):
Prepared biofertilizer was evaluated in the farmer's field of Rajshahi, Barisal and Kishoreganj. Farmer's field was surveyed and demonstrations trials were done with the farmer's participation in T. Amanrice grown in 2017. Four farmers were selected from each location.

Farmer's field demonstration trial at Rajshahi
Two locations at Poba and one location each at Godagari and Durgapur were selected for farmer's field demonstration trial. The demonstration trial result of Rajshahiis given in Table 11. At Poba, one trial was conducted on Golam Ambia's field. The soil of his field contained 1% organic C, 0.09% total N, 26.21 ppm available P, 0.10 meq /100 g soil exchangeable K and 12.12 ppm available sulfur. The result of demonstration trial showed 6.25% yield increase in T_1 (BF+NKS, 70%) application field compared to full chemical fertilizer treatment (T_2). The second trial was conducted on Ibne Khalid's field at Poba. The soil contained 1.0% organic C, 0.1% total N, 24.12 ppm available P, 0.14 meq/100g soil exchangeable K and 12.11 ppm available sulfur. The result showed 13% yield increase due to biofertilizer application with 30% reduced chemical fertilizer. The trial at Godagari was damaged due to a sudden stormspell just 3 days before crop harvest. Even thoughthere was a yield increment in biofertilizer applied plot (T_1).The 4th trial was conducted at Durgapur, Md. Alamgir's field. The organic C of his field soil was 1.10%, total N, 0.10%, available P, 35 ppm, Exchangeable K, 0.14 meq/100 g soil and available sulfur 13.14 ppm. About 9% yield increment was found in this field trial at T_1 treatment.

Table 11: Farmer's demonstration field trial at Rajshahi (Rice variety: BRRI dhan71)

Farmers' name	Location	Date	Treat	Tiller m^{-2}	Panicle m^{-2}	Grain Yield (t ha^{-1})	Straw yield (t ha^{-1})
Golam Ambia	Poba	Transplanting: 31/7/17 Harvest: 4/11/17	T_1	247	220	**4.25**	5.79
			T_2	248	228	4.01	5.70
Shadat Hossain	Godagari	Transplanting: 31/7/17 Harvest: 4/11/17	T_1	250	172	**2.31**	3.66
			T_2	244	164	2.06	3.02
Md. Alamgir	Durgapur	Transplanting: 11/8/17 Harvest: 5/11/17	T_1	152	145	**4.07**	4.29
			T_2	122	114	3.72	4.54
Ibne Khalid	Poba	Transplanting: 31/7/17 Harvest: 6/11/17	T_1	180	169	**3.64**	3.67
			T_2	172	169	3.22	3.79

T_1=BF+NKS (70%), $T_{2=}$ Farmers' practice (NPKS kg/ha@ 67-10-41-10).

Picture: Farmer's demonstration field trial at Rajshahi

Farmer's field demonstration trial at Kuakata, Najirpur, and Borguna

The field demonstration result is given in Table 12. Shadiul Islam's field was selected for the demonstration trial at Kuakata. The field soil was poor in nutrient content, organic C (0.68%) total N (0.07%) and available P (5.31 ppm). The sulfur content was 24.06 ppm and exchangeable K was 0.24 meq/100 g soil. In this soil application of biofertilizer with 30% reduced chemical fertilizer (T_1) gave 10% yield increment. The selected Nazirpur farmer's field was submerged prone saline soil. At the seedling stage, field was submerged for 18 days. BRRI dhan52 was cultivated in this field. The field of Elias Mir had low in organic C (0.78%), total N (0.07%), available P (5.12 ppm), exchangeable K (0.26 meq/100 g soil) and available sulfur (26.31 ppm). However 3% higher yield was obtained in T_1 treatment. Borguna farmer's field soil was also low in organic C (0.81%), total N (0.08%), available P (6.00 ppm), exchangeable K (0.25 meq/100 g soil) and available sulfur (26.02 ppm). BRRI dhan54 was cultivated and got about 10% yield increment in T_1 treatment. Md. Kabul Sheikh at Najirpur also cultivated BRRI dhan52 and crop was submerged for 18 days at seedling stage. His field soil contained 0.78 % organic C, 0.08% total N, 5.01 ppm available P, 0.25 meq/100g soil exchangeable K and 25.13 ppm available sulfur. About 14% yield benefit was recoded in T_1 treatment.

Table 12: Farmer's field demonstration trial at Kuakata, Borguna and Najirpur

Farmers' name	Location	Variety	Date	Treat	Tiller m^{-2}	Panicle m^{-2}	Grain Yield (t ha^{-1})	Straw yield (t ha^{-1})
Shahidul Islam	Kuakata	BRRI dhan49	Transplanting: 18/8/17 Harvest: 17/11/17	T_1	256	248	**3.85**	4.37
				T_2	305	247	3.49	4.92
Elias Mir	Nazirpur	BRRI dhan52	Transplanting: 7/9/17 Harvest: 5/12/17	T_1	336	252	**4.63**	5.82
				T_2	350	300	4.49	5.61
Md. Al- Amin	Borguna	BRRI dhan54	Transplanting: 5/8/17 Harvest: 17/11/17	T_1	352	339	**5.66**	4.72
				T_2	327	309	5.14	5.55
Md. Kabul Seikh	Nazirpur	BRRI dhan52	Transplanting: 19/8/17 Harvest: 2/12/17	T_1	-	-	**3.89**	-
				T_2	-	-	4.52	-

T_1=BF+NKS (70%), T_2= Farmers' practice (NPKS kg/ha@ 67-10-41-10).




Picture: Farmer's demonstration field trial at Kuakata, Borguna and Najirpur

Farmer's field demonstration trial atKotiadiKisorganj

Four field trials were also conducted at Kotiadi Kisorganj (Table 13). Md. Samsuddin cultivated BRRI dhan71.Field soil contained organic C (1.15%),total N (0.12%), available P (22.31 ppm), exchangeable K (0.11meq/100 g soil) and available sulfur (12.56 ppm). Yield was recorded 4.66 t/ha (T_1) with biofertilizer + 30% reduced NKS fertilizer and 4.38 t/ha in only chemical fertilizer (T_2) applied treatment. The demonstration field soil of Jwel Rana contained organic C (1.20%), total N (0.11%), available P (22.11 ppm), exchangeable K (0.13 meq/100 g soil) and available sulfur (13.13 ppm). BRRI dhan75 was cultivated and about 11% yield benefit was recorded in (T_1) treatment. Robi Mian also cultivated BRRI dhan75 and about 10.67% yield increment was obtained in same (T_1) treatment. Field soil of this demonstration contained organic C (1.13%), total N (0.11%), available P (21.20 ppm), exchangeable K (0.12 meq/100 g soil) and available sulfur (12.56 ppm). The field soil of Abul Kalam contained organic C (1.11%), total N (0.11%), available P (21.20 ppm), exchangeable K (0.12 meq/100 g soil) and available sulfur (12.13 ppm).BRRI dhan49 was cultivated in this soil and about 3% yield benefit was obtained in T_2 plot.

Table 13: Farmer's field demonstration trial at Kotiadi Kisoregonj

Farmers' name	Date	Variety	Treat	**Tillerm $^{-2}$**	**Panicle m $^{-2}$**	**Grain Yield (t ha $^{-1}$)**	**Straw yield (t ha $^{-1}$)**
Md. Samsuddin	Transplanting: 5/8/17 Harvest: 31/10/17	BRRI dhan71	T_1	342	283	**4.66**	5.49
			T_2	323	222	4.38	4.68
Jewel Rana	Transplanting; 5/8/17 Harvest: 9/11/17	BRRI dhan75	T_1	172	133	**3.08**	4.07
			T_2	161	127	2.77	3.77
RobiMian	Transplanting: 5/8/17 Harvest: 9/11/17	BRRI dhan75	T_1	273	236	**3.42**	3.32
			T_2	288	239	3.09	2.81
AbulKalam	Transplanting: 5/8/17 Harvest: 27/11/17	BRRI dhan49	T_1	284	281	4.53	5.33
			T_2	290	278	**4.66**	5.56

T_1=BF+NKS (70%), $T_{2=}$ Farmers' practice (NPKS kg ha^{-1}@ 67-10-41-10).

Picture: Farmer's field demonstration trial at Kotiadi Kisorganj

On research station trial (Boro season)

In the Boro season of 2017-18, three field trails were conducted at BRRI Gazipur, BRRI R/S Cumilla and BRRI R/S Barisal.BRRI dhan58 was cultivated in all three locations. In Gazipur soil the highest yield (6.04 t/ha) was obtained in T_2 treatment (chemical fertilizer) which was statistically similar to (6.04 t/ha) T_3 treatment where BF + 70% reduced NKS fertilizer was used. The grain yield trend was similar in Cumilla R/S. The highest grain yield was obtained in T_3 (8.67 t/ha) and it was statistically similar to T_2 (8.31 t/ha) treatment. At Barisal R/S statistical similar grain yield was obtained in T_1, T_2 and T_3 treatments. The lowest grain yield was recorded in control treatment.

The yield trend of three research station revealed a significant effect of biofertilizer on grain yield (Figure 2).

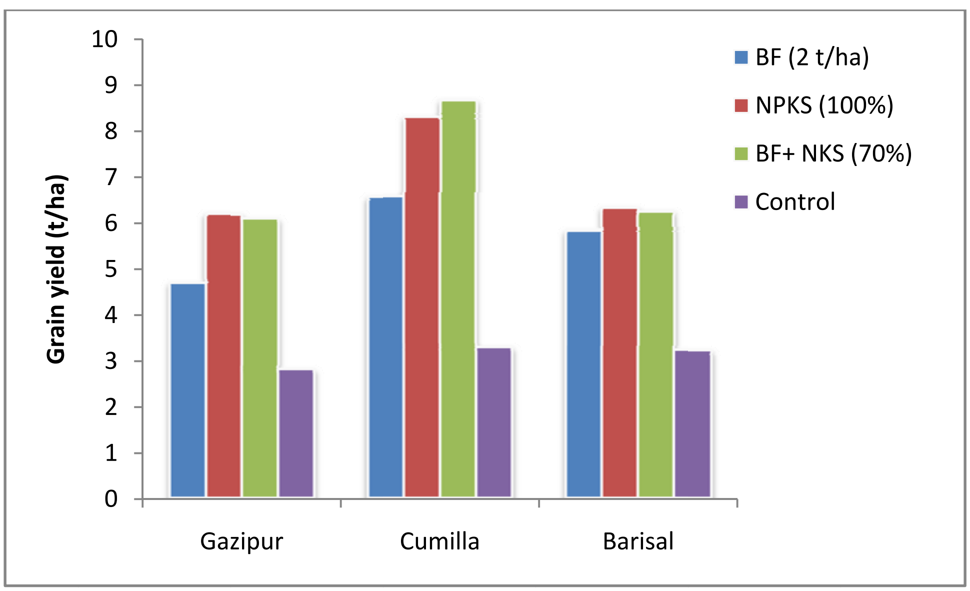


Figure 2: Effect of biofertilizer on rice yield at Gazipur, BRRI R/S Cumilla and BRRI R/S Barisal (variety BRRI dhan58) at Boro 2017-18. *NPKS kg/ha@ 120-15-60-10

Farmer's field demonstration trial at Amtali, Barguna and Dacope, Khulna (Boro season)

At Amtali, Barguna site, application of biofertilizer @2 t ha^{-1} (dry weight basis) along with 30% reduced urea and 100% removal of TSP fertilizer increased panicle number (9%), filled grain/panicle (17%) and rice yield about 1 t/ha (22.3%) compared to full chemical fertilizer of BRRI dhan67 (Figure 3). Whereas, in Dacope, Khulna site, biofertilizer increased panicle number (20%), filled grain per panicle (1%), and also rice yield by 1 t/ha (15.3%) compared to balanced chemical fertilizer of BRRI dhan67 (Figure 3).

Above findings from Amtali and Dacope showed that biofertilizer was capable of improving rice yield in saline soil where irrigation water salinity varied from 0.65-2.53 dS/m with the corresponding soil salinity raged from 6.59-8.96 dS/m.

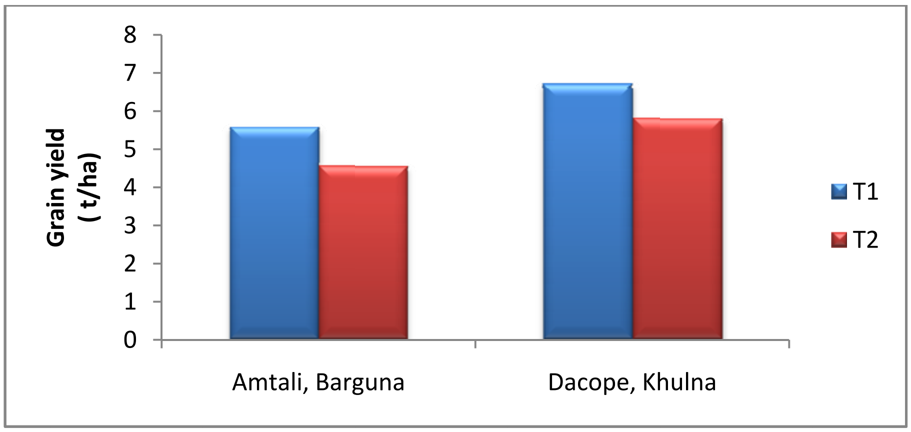


Figure 3: Effect of biofertilizer on rice yield at Amtali, Barguna and Dacope, Khulna (variety BRRI dhan67) at Boro 2017-18.

T_1=BF+NKS (70%), $T_{2=}$ Farmers' practice (NPKS kg/ha@ 140-20-80-10 kg ha^{-1}).

Effect of biofertilizer application on soil biology

Microbial activity is an indicator of soil health. We determined the microbial populations of the experimental soil and farmers' field soil after establishment of the experiment. Study report showed that application of biofertilizer significantly increased free living N_2 fixing and phosphate solubilizing bacteria population which indicated survival of the applied bacteria in the field condition (Table 14 to Table 19).

On research station trial (BRRI Gazipur)

Application of biofertilizer along with or without chemical fertilizer significantly increased free-living N_2 fixing (NFB) and PSB population compared to control and chemical fertilizer applied plot (Table 14). The highest NFB population was found in T_8 (Soil inoculation) treatment and it was statistically similar to other biofertilizer applied plot. The lowest NFB population was found in the control treatment. The highest PSB population was also found in T_8 (Soil inoculation) treatment which was statistical similar to $T_{2,}$ $T_{3,}$ andT_4 treatments. Result showed that application P nutrient increased survival of applied PSB via biofertililizer.

BRRI R/S Rajshahi

Initial soil microbial population and after harvest is given in Table 15. Application of biofertilizer increased NFB population compared to chemical fertilizer and initial soil. The population of PSB and NFB was also increased compared to initial soil.

Table 14. Effect of biofertilizer and chemical fertilizer on soil microbial population at BRRI, Gazipur

Treatment	Total bacteria	Fungus	Actinomycetes	Free living N_2-fixing bacteria	Phosphate solubilizing bacteria
T1	$3.3x10^7$a	$4.4x10^5$abc	$2.0x10^1$ab	$3.2x10^4$c	$1.9x10^4$bc
T2	$2.0x10^7$a	$3.6 x10^5$bc	$2.7x10^1$ab	$4.1x10^4$b	$2.1x10^4$abc
T3	$3.0x10^7$a	$4.8x10^5$abc	$3.4x10^1$a	$4.5x10^4$ab	$2.0x10^4$abc
T4	$2.6x10^7$a	$3.2x10^5$c	$1.3x10^1$b	$5.3x10^4$ab	$2.4x10^4$ab
T5	$2.2 x10^7$a	$7.1x 10^5$a	$2.2x10^1$ab	$3.5x10^4$b	$1.8x10^4$c
T6	$2.4 x10^7$a	$6.0x10^5$ab	$1.2x10^1$b	$6.3x10^4$a	$1.8 x 10^4$c
T7	$2.2 x10^7$a	$5.0x10^5$abc	$1.0x10^1$b	$6.6x10^4$a	$1.7 x10^4$c
T8	$1.2 x 10^7$a	$5.6x10^5$abc	$2.5x10^1$ab	$6.7x10^4$a	$2.5x10^4$a
Initial soil	$4.0 x 10^5$	$4.6x10^5$	$1.0x10^1$	$4.0x10^3$	$1.4x10^4$
CV	41.68	29.39	52.62	36.85	13.79

T_1=control, T_2= NPKS (100%) **, T_3= NKS (100%), T_4=BF + NKS (100%), T_5= NPKS (75%), T_6= BF+ NKS (75%), T_7= BF*, T_8= Soil inoculation, * BF 2 t/ha, **NPKS kg/ha@ 67-10-41-10.

PSB= Phosphate sloubilizing bacteria, NFB= Free- living N_2 fixing bacteria.

Table 15. Effect of biofertilizer and chemical fertilizer on soil microbial population at BRRI R/S Rajshahi

Treatment	Total bacteria	Fungus	Actinomycetes	Free living N_2-fixing bacteria	Phosphate solubilizing bacteria
T_1	$2.13 x 10^7$ b	$4.06 x 10^5$ a	$4.62 x 10^4$	$3.51 x 10^5$ a	$2.94 x 10^4$ a
T_2	$1.47 x 10^7$ b	$2.82 x 10^5$ a	$2.86 x 10^4$	$2.06 x 10^4$b	$2.68 x 10^4$a
T_3	$6.08 x 10^7$ a	$1.09 x 10^5$ b	$1.65 x 10^4$	$3.11 x 10^4$b	$2.64 x 10^4$a
T_4	$2.09 x 10^7$ b	$1.09 x 10^5$ b	$1.09 x 10^4$	$1.83 x 10^4$c	$1.59 x 10^4$b
Initial population	$1.47 x 10^7$	$1.65 x 10^5$	$1.62 x 10^4$	$1.80 x 10^4$	$1.74 x 10^4$
CV (%)	28.86	36.52	72.56	48.15	13.93

T_1=BF (2 t/ha), T_2= NPKS (100%)*, T_3= BF+ NKS (70%), T_4= Control, *NPKS kg/ha@ 120-15-60-10

BRRI R/S Barisal

The population of PSB and NFB was significantly increased due to application of biofertilizer in Barisal farm (Charbodna). The increased bacteria population due to application of biofertilizer indicates the improvement of soil biology. The applied NFB strains were capable to fix atmospheric N_2 and continuous supply of N ensured higher yield compared to chemical fertilizer. The soil biology of BRRI R/S Barisal farm (Charbodna) is described in Table 16.

Table 16. Effect of biofertilizer and chemical fertilizer on soil microbial population at BRRI R/S Barisal

Treatment	Total bacteria	Fungus	Actinomycetes	Free living N_2-fixing bacteria	Phosphate solubilizing bacteria
T_1	1.96×10^7	3.29×10^3 a	4.35×10^2	8.03×10^5a	2.35×10^4a
T_2	1.77×10^7	1.53×10^3 b	3.55×10^2	1.87×10^4b	5.10×10^3b
T_3	1.80×10^7	1.68×10^3 b	4.26×10^2	8.09×10^5a	1.13×10^4a
T_4	1.18×10^7	9.31×10^2 b	1.86×10^2	1.37×10^3b	3.34×10^3b
Initial population	1.82×10^7	2.73×10^3	1.82×10^2	1.55×10^4	3.82×10^3
CV (%)	54.83	40.17	91.73	37.7	70.51

T_1=BF (2 t/ha), T_2= NPKS (100%)*, T_3= BF+ NKS (70%), T_4= Control, *NPKS kg/ha@ 120-15-60-10

Farmer's field demonstration trial at Kotiadi, Kisoregonj

Application of biofertilizer increased PSB and NFB population at the field of Jwel Rana, Robi Mia and Samsuddin's compared to Abul Kalam (Table 17). It was also noticed that lower yield was obtained in biofertilizer applied plot compared to chemical fertilizer application at Abul Kalam's field.

Table 17. Effect of biofertilizer and chemical fertilizer on soil microbial population at Farmer's field demonstration trial (Kotiadi, Kisoregonj)

Farmers' Name	Treatment	Total bacteria	Fungus	Actinomycetes	Free living N_2-fixing bacteria	Phosphate solubilizing bacteria
Jewel Rana	T_1	$5.4x10^6$	$3.6x10^3$	$3.6x10^2$	$1.4x10^5$	$8.0x10^4$
	T_2	$3.6x10^6$	$1.8x10^3$	$3.6x10^2$	$1.4x10^4$	$6.6x10^3$
Abul Kalam	T_1	$9.6x10^6$	$1.6x10^3$	$1.5x10^5$	$1.9x10^4$	$7.8x10^5$
	T_2	$6.6x10^6$	$1.6x10^3$	$1.6x10^2$	$1.1x10^4$	$9.0x10^4$
Robi Mia	T_1	$1.9x10^6$	$1.6x10^3$	$1.6x10^2$	$9.8x10^4$	$3.2x10^4$
	T_2	$1.5x10^6$	$1.5x 10^3$	$1.5x10^2$	$9.0x10^3$	$3.3x10^3$
Samsuddin	T_1	$3.2x10^6$	$1.6x10^3$	$1.6x10^2$	$9.7x10^4$	$4.9x10^4$
	T_2	$1.6x10^6$	$1.6x10^3$	$1.6x10^2$	$6.5x10^3$	$3.3x10^3$

T_1=BF+NKS (70%), $T_{2=}$ Farmers' practice (NPKS kg/ha@ 67-10-41-10).

Farmer's field demonstration trial at Rajshahi region

At Rajshahi, application of biofertilizer increased PSB and NFB population of Md. Alamgir, Golam Ambia and Shadat Hossain field. The data obtained are given in Table 18. Among the tested field soil, the soil biology of Md. Alamgir's field was comparatively good than other three farmers.

Table 18. Effect of biofertilizer and chemical fertilizer on soil microbial population at Farmer's field demonstration trial (Rajshahi region).

Farmers' Name	Treatment	Total bacteria	Fungus	Actinomycetes	Free living N_2-fixing bacteria	Phosphate solubilizing bacteria
Md. Alamgir	T_1	$1.7x10^8$	$2.6x10^3$	$7.9x10^2$	$5.6x10^4$	$5.5x10^4$
	T_2	$1.3x10^8$	$3.2x10^3$	$2.1x10^2$	$1.8x10^4$	$6.4x10^3$
Ibne Khalid	T_1	$5.5x10^6$	$6.9x10^3$	$1.4x10^4$	$1.4x10^4$	$2.2x10^4$
	T_2	$2.4x10^6$	$3.5x10^3$	$3.5x10^4$	$2.4x10^4$	$2.0x10^4$
Golam Ambia	T_1	$6.7x10^6$	$3.4x10^3$	$2.2x10^4$	$1.6x10^4$	$8.5x10^4$
	T_2	$4.2x10^6$	$2.1x10^3$	$1.1x10^4$	$1.3x10^4$	$1.2x10^3$
Shadat Hossian	T_1	$8.7x10^6$	$2.4x10^3$	$2.5x10^4$	$2.8x10^4$	$9.8x10^4$
	T_2	$5.2x10^6$	$2.7x10^3$	$1.6 x10^4$	$1.9x10^4$	$6.2x10^3$

T_1=BF+NKS (70%), $T_{2=}$ Farmers' practice (NPKS kg/ha@ 67-10-41-10).

Farmer's field demonstration trial at Barisal region

Apparently, status of soil biology was good in Barisal region compared to other soil. The high number of total bacteria was recorded in Elias Mir field. A considerable number of NFB and PSB was population also found in all tested sites. Application of biofertilizer also increased the desired bacteria population. Population of bacteria and other microbes were given in Table 19.

Table 19. Effect of biofertilizer and chemical fertilizer on soil microbial population at Farmer's field demonstration trial (Barisal region).

Farmers' Name	Treatment	Total bacteria	Fungus	Actinomycetes	Free living N_2-fixing bacteria	Phosphate solubilizing bacteria
Kabul Seikh	T_1	$9.6x10^7$	$3.6x 10^3$	$1.8x10^2$	$9.0x10^5$	$6.4x10^4$
	T_2	$6.8x10^7$	$1.8x 10^3$	$3.6x10^2$	$3.6x10^4$	$3.2x10^4$
Elias Mir	T_1	$1.4x10^8$	$4.8x 10^3$	$1.4x10^3$	$3.2x10^5$	$1.5x10^6$
	T_2	$1.4x10^8$	$1.6x 10^3$	$1.8x10^3$	$8.0x10^4$	$2.3x10^5$
Al Amin	T_1	$4.8x10^7$	$1.2x 10^3$	$3.7x10^2$	$7.4x10^5$	$4.0x10^6$
	T_2	$6.5x10^7$	$1.2x 10^3$	$9.8x10^2$	$9.8x10^4$	$5.8x10^5$
Sahidul Islam	T_1	$6.0x10^7$	$1.8x 10^3$	$1.8x10^2$	$1.5x10^6$	$4.0x10^6$
	T_2	$9.6x10^7$	$3.6x 10^3$	$1.8x10^2$	$1.6x10^5$	$3.6x10^5$

T_1=BF+NKS (70%), $T_{2=}$ Farmers' practice (NPKS kg/ha@ 67-10-41-10).

Farmers Field Day and Farmers Opinion

A field day and crop cut was arranged at Poba Rajshahi farmer's field (Golam Ambia). Head BRRI R/S Rajshahi, Agricultural Extension Officer and Field assistants were present in that program. A total number of 60 farmers participated in the program; among them 40 was male and 20 female. In front of farmers and participants crop cut was done and yield data were recorded.

Picture: Farmer's field day at Rajshahi

A questioner was prepared to get farmers opinion about the uses of biofertilizer. Survey was conducted at Rajshahi, Pirojpur and Kishoreganj. The farmers opinions were ranked as 'good', 'fair' and 'Bad' (Table 22), and result expressed as percentage. The overall reaction about odor of biofertilizer was good, all of the farmers were happy to use biofertilizer as they got yield benefit. For easy application, 2-5% farmers demanded granular form biofertilizer. The farmers were willing to use this biofertilizer in future. If price would be within 10 taka then they would be interested to apply in their field.

Table 20. Farmers Opinion (%) about the applied biofertilizer

Questions	Rajshahi			Najirpur, Pirojpur			Kishoreganj		
	Good	Fair	Bad	Good	Fair	Bad	Good	Fair	Bad
Odor	100	0	0	100	0	0	100	0	0
User friendly	98	2	0	100	0	0	95	5	0
Yield Benefit	100	0	0	100	0	0	99	1	0
Intend to use if product is available	100	0	0	100	0	0	100	0	0
Market price 10 tk/kg	100	0	0	100	0	0	100	0	0

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

- Twenty eight potential plant growth promoting bacteria (PGPB) were isolated from favorable and unfavorable (saline and acid soil) ecosystem (Lalmonirhat, Rajshai, Barisal, Patuakhali, Kuakata, and Gazipur).Isolated PGPB strains were able to fix N_2 (100-1600 ppm), solubilize P (300-1300ppm) and produce IAA (0.003-0.028%) in broth culture.
- Among them seven were identified using 16S rRNA gene sequencing as;*Bacillus mycoides*(acid soil), *Proteus sp.* (acid soil),*Bacillus cereus* (acid soil), *Bacillus Subtilis* (favouable ecosystem), *Bacillus pumilus* (acid soil), *Paenibacillus sp.* (saline soil),and *Paenibacilluspolymyxa*(favorable ecosystem).
- Three ton biofertilizer was prepared with isolated 10 potential PGPB strains. Degradable Kitchen/ chaccha bazar waste material, 15% biochar (chitadhan), and 5% rock phosphate were used as carrier material of the biofertilizer. Prepared biofertilizer was applied to the research stations and farmers field for validation.
- The biofertilizer application saved 25-30% chemical N fertilizer (Urea) for rice production

- Biofertilizer completely eliminate (100%) TSP fertilizer use in rice production and promoted natural source of rock phosphate for rice production in Bangladesh (5% rock phosphate is the active ingredient of the biofertilizer).
- The post soil analyses data (after harvesting of crop) proved applied biofertilizer improved soil biology with free-living N_2 fixing and phosphate solubilizing bacteria.
- Biofertilizer tested in different farmer's field at Rajshahi, Barisal, Kishoreganj, Dacope, Khulna and Amtoli, Barguna proved that rice yield increased by 2 to 20% at different locations with30% reduced chemical N and without (100%) TSP fertilizer.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment 1. Scanner 2. Printer	 1 1	 10000 20000	 1 1	 13500 16400	 100 (%) 100 (%) (Price re-fixed as per BRRI Procurement committee)
(b) Lab &field equipment 1. Chemicals, media and lab Glassware 2. Identification of Bacteria	Lump 7	643265 30000	Lump 7	592640 30000	 100 (%) 100 (%) (As per BRRI Procurement committee)
(c) Other capital items 1. Bioreactor 2. Rice Straw Grinder	 1 1	 420000 150000	 1 1	 416000 149000	 100 (%) 100 (%) (As per BRRI Procurement committee)

3. Establishment/renovation facilities: Not eligible

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
-	-	-	-	-	-

4. 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	444690	444690	444690	0	100	-
B. Field research/lab expenses and supplies	1194452	1021277	1021277	0	100	-
C. Operating expenses	200576	198571	194326	4245	100	Bank operation
D. Vehicle hire and fuel, oil & maintenance	177603	173103	173103	0	100	-
E. Training/workshop/seminar etc.	140100	133100	133100	0	100	-
F. Publications and printing	85000	73000	5000	68000	0	PCR cost return to BARC, NATP-2
G. Miscellaneous	41679	39939	39939	0	100	-
H. Capital expenses	594900	594900	594900	0	100	-

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

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
i) To Isolate and bio-molecular characterize of free-living N_2 fixing and Phosphate solubilizing bacteria from favorable and unfavorable rice ecosystem	Twenty eight PGPB strains were isolated and characterized from saline, acid and barind soil Capability of N_2 fixation, phosphate solubilisation and IAA production of isolated PGPB were determined Molecular identification of seven potential PGPB	Report, Data, isolated strains were preserved in -56^{o}C refrigerator Data, Report Gene sequencing, Reporting	Twenty eight potential PGPB strain were isolated which could be used as biofertilizer Potentiality of indigenous PGPB were determined Seven strains were identified using molecular tool
ii)To improve biofertilizer with potential bacterial strains	About 3 ton of Biofertilizer was prepared using 10 potential strains	Biofertilizer	Biofertilizer was applied to the research station and farmers field

iii) to evaluate efficacy of biofertilizer to promote rice plant growth and yield and to find appropriate dose of chemical fertilizer	Three field experiments were conducted at BRRI Gazipur, BRRI regional station Rajshahi and Barisal. Twelve demonstrations were conducted at the farmer's field of Borguna, Kuakata, Pirojpur, Kisorganj, and Rajshahi.	Crop yield data, report, leaflet, reporting at News paper	Field evaluation of biofertilizer performed and following outcome documented: Biofertilizer • Capable to reduce 30% urea use • Eliminate 100% TSP use for rice production • Promote rock phosphate for rice production • Improved rice yield 5-10%
iv) to improve soil biology	Population of total bacteria, free-living N_2 fixing bacteria, phosphate solubilizing bacteria, fungus and actinomycetes were determined Plant nutrient uptake and soil chemical properties was analyzed	Data, Report etc	Biochemical properties of field soil (initial and after crop harvest) were analyzed Social impact of biofertilizer was surveyed

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	
Technology bulletin and leaflet	-	2	1.“Bio-organic fertilizer for rice production-Urea and TSP saving technology”published in BRRI Newsletter, July-September 2017. 2. **Leaflet:**ধান চাষে বায়ো-অর্গানিক সারের ব্যবহারঃ ইউরিয়া ও টিএসপিসাশ্রয়ী প্রযুক্তি- **3. Poster:** Bio-organic fertilizer: A green technology to improve soil health and rice yield
Journal publication	2	-	-
Information development	1		Biofertilizer for rice production with 30% reduced urea and without TSP

Other publications, if any	-	**News at daily news paper**	1. Daily Star (26/09/2017) 2. Daily Observer (27/9/2017) 3. Daily Ittefaq (26/09/2017) 4. Jonokontho (29/9/2017) 5. The Sun(01/10/2017) 6. Jai-Jai DIN (01/10/2017)

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

i. Generation of technology (Commodity)

Biofertilizer (BRRI bio-organic biofertilizer)
It is a green technology to reduce 30% urea and eliminate 100% TSP fertilizer use in rice production. Application of biofertilizer @ 2 ton/ha increased 5-20% rice yield and improved soil health.

ii. **Generation of new knowledge that help in developing more technology in future**

- Promote rock phosphate for rice cultivation
- Use of indigenous plant growth promoting bacteria (PGPB) to improve crop productivity and soil health
- Appropriate technology to manage and recycle kitchen waste and improve soil organic carbon sequestration
- Way to reduce greenhouse gas emission due less use of chemical fertilizer use

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

BRRI Bio-organic fertilizer

iv. Policy Support

Biofertilizer for sustainable rice production

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	12th August, 2017 5th March, 2018	2	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) Director General BRRI 2) Director Research BRRI 3) Field visit by Agriculture Officer	18th July, 2017 (BRRI Gazipur) 5th November 1017 (Rajshahi) 6th November 2017 (PobaRajshahi)	3	Highly Satisfied

Signature of the Principal Investigator
Date ………………………….
Seal

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

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Appendix

B. mycoides

>SL2_F

CATGGATAACAGATACCATGTTAGTCGGAGGTAGCACAGAGGGACTTGGC
CCCTCGGGAGAAGAGTGGCGCGCGGGTGAAAAGTGTGGGGGTCTCTGCCC
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Proteus sp:
>SL3_F
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Bacillus cereus
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Some important Documents

সারণী-৩. আমন মৌসুমে ব্রি ধান চাষে, কৃষকের মাঠে বায়োফার্টিলাইজারের প্রভাব (প্রয়োগ মাত্রা ২ টন/হেঃ)

কৃষকের নাম	প্রদর্শনের স্থান	ধানের ফলন (টন/হেঃ)	
		(T_1)	(T_2)
শহীদুল ইসলাম	কুয়াকাটা,পটুয়াখালী	৩.৫	৩.৮
ইলিয়াস মীর	নজিরপুর, পিরোজপুর	৪.৫	৪.৬
মোঃ আলামিন	আমতলী, বরগুনা	৫.৭	৫.৭
গোলাম আম্বিয়া	পবা, রাজশাহী	৪.০	৪.৩
মোঃ আলমগীর	দূর্গাপুর, রাজশাহী	৩.৭	৪.১
ইবনে খলিদ	পবা, রাজশাহী	৩.২	৩.৬
মোঃ সামসুদ্দিন	কটিয়াদী, কিশোরগঞ্জ	৪.৪	৪.৭
রবি মিয়া	কটিয়াদী, কিশোরগঞ্জ	৩.১	৩.৪

T_1= শতভাগ রাসায়নিক সার, কেজি/হেঃ (ইউরিয়া-টিএসপি-এমওপি-জিপসাম @১৪৫-৫০-৮২-৫৬),
T_2= বায়োফার্টিলাইজার (২টন/হেঃ) + রাসায়নিক সার, কেজি/হেঃ (ইউরিয়া- টিএসপি- এমওপি-জিপসাম @ ১০৯-০-৮২-৫৬)

ধান চাষে বায়োফার্টিলাইজার ব্যবহারের সুবিধাঃ

১। শতকরা প্রায় ২৫-৩০ ভাগ নাইট্রোজেন সার সাশ্রয় হয় ।
২। টিএসপি সার ব্যবহারের প্রয়োজন নেই।
৩। জৈব পদার্থ ও বায়োচার সমৃদ্ধ হওয়ায় মাটিতে কার্বনের পরিমান বৃদ্ধিসহ মাটির সু-স্বাস্থ্য বজায় থাকে।
৪। মাটিতে প্রচুর পরিমাণে উপকারী অণুজীব সংযুক্ত হবে যা মাটির স্বাস্থ্য রক্ষা, গুণাগুণ বৃদ্ধি ও ফসলের ফলন বৃদ্ধির জন্য আবশ্যক।
৫। রান্না ঘরের পচনশীল বর্জ্য, কাঁচা বাজারের শাকসবজি ও ফলমুলের অবশিষ্টাংশ জৈব পদার্থরূপে ব্যবহার হওয়ায় পরিবেশ দূষণ কম হবে।
৬। উৎপাদন প্রক্রিয়া সহজ ও পরিবেশ বান্ধব।

বিস্তারিত তথ্যের জন্য যোগাযোগ করুন
মৃত্তিকা বিজ্ঞান বিভাগ
বাংলাদেশ ধান গবেষণা ইনস্টিটিউট,
গাজীপুর-১৭০১।
ফোনঃ ৮৮০-২-৪৯২৭২০০৫-৯, ৪৯২৭২০১০-৩৮
ফ্যাক্সঃ ৮৮০-২-৪৯২৭২০০০
E-mail: naher39@gmail.com
Website: www.brri.gov.bd

মাটির উর্বরতা বৃদ্ধি, স্বাস্থ্য রক্ষা ও অধিক ফলনের জন্য পরিবেশ বান্ধব বায়োফার্টিলাইজারের ব্যবহার

রচনায় ও সম্পাদনায়
ড. উম্মে আমিনুন নাহার
প্রধান বৈজ্ঞানিক কর্মকর্তা
মো: ইমরান উল্লাহ সরকার
বৈজ্ঞানিক কর্মকর্তা

প্রকাশনায়
মৃত্তিকা বিজ্ঞান বিভাগ
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RICE FARMING

A green way to cut cost

- BRRI developed new bio-organic fertiliser
- To eliminate TSP use, cut urea use by 30pc
- To ease burden of fertiliser subsidy
- To help keep environment green

REAZ AHMAD

Bangladeshi scientists have developed the perfect blend of decomposable waste, biochar, friendly bacteria and rock phosphate to make two most-used chemical fertilisers in the country's paddy fields largely unnecessary.

A group of soil scientists at the Bangladesh Rice Research Institute (BRRI) yesterday said use of the newly developed bio-organic fertiliser would eventually eliminate 100 percent usage of triple super phosphate (TSP) and reduce urea usage for rice production by 30 percent.

Not only would this help reduce the use of chemical fertiliser, it would significantly cut the government's yearly fertiliser subsidy of Tk 9,000 crore.

It would also help keep the environment clean and green as it would use kitchen waste and cut down carbon emission.

The Soil Science Division of BRRI successfully field-tested the efficacy of this bio-organic fertiliser on paddy in all three rice-growing seasons -- Boro,

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A green way to cut cost

FROM PAGE 1

Aus and Aman.

The tests were done over the last one year at BRRI's compound and the fertiliser is now on trial at farmers' fields in Barisal, Patuakhali, Rajshahi and Kishoreganj.

Umme Aminun Naher, a BRRI principal scientific officer (PSO) and mastermind behind the bio-organic fertiliser, told The Daily Star yesterday that the blend has 10 beneficial bacteria.

About 15 percent of it is biochar (charcoal used as a soil amendment) and five percent rock phosphate, she said, adding that the rest was decomposable household vegetable waste.

She said their trials had shown that the use of bio-organic fertiliser did not have any impact on rice yields and was at par with production level achieved through chemical fertiliser usage.

Naher pointed out that the fertiliser would help reduce carbon emissions. Greenhouse gasses are emitted during chemical fertiliser production and its use, she said.

Research revealed that the production of one kg of urea and TSP fertiliser emits about six kg of CO2 in the air, said the Unesco-ISTIC (International Science, Technology and Innovation Centre for South-South Cooperation) award-winning scientist.

She said, "We are using the same rock phosphate, which is a key ingredient in TSP, but in our process the beneficial bacteria make the rock phosphate soluble. Other bacteria that we are using help compost waste, fix nitrogen from the air and help the paddy plant grow."

The biochar is produced by burning rice husk, she added.

Neither Naher nor Jatish Chandra Biswas, the head of the BRRI Soil Science Division, could give a clear idea on the cost of the fertiliser.

They, however, said the cost of production should be much lower than chemical fertilisers as "we are using household wastes, cheap biochar and bacteria and little amount of rock phosphate, which is available in the market for Tk 5 per kg".

They said the fertiliser would add organic matter and beneficial microbes to maintain soil health. Soil quality would increase with direct application of carbon via biochar.

Research findings indicate that application of chemical fertilisers for a long time decreases the populations of free-living nitrogen fixing bacteria, organisms that solubilise phosphate as well as other beneficial bacteria.

Md Imran Ullah Sarkar and Afsana Jahan are the two other soil scientists of the BRRI team that developed the fertiliser after several years of research, lab tests and field trials.

Jatish told The Daily Star that to move forward with the product, BRRI would first make a patent application. Once they had the patent, they would provide interested enterprises with the technology so that the fertiliser reached all farmers in the country.

The decomposing process of the waste, bacteria, biochar and phosphate would generate a considerable amount of biogas and people would be able to tap into it, once it is produced commercially on a large scale, he said.

BRRI Director General Md Shahjahan Kabir told The Daily Star yesterday that as a first step, BRRI would soon approach the Gazipur City Corporation to go for bio-organic fertiliser production.

"We are (BRRI headquarters) located in Gazipur and we will approach the local city authorities to make the best use of the decomposable waste collected each day. That will have a demonstrative effect on other places in the country," said Kabir.

দৈনিক ইত্তেফাক
প্রতিষ্ঠাতা তফাজ্জল হোসেন মানিক মিয়া
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ধান আবাদে পরিবেশবান্ধব বায়ো-অর্গানিক সার উদ্ভাবন

টিএসপি লাগবে না, ইউরিয়ার ব্যবহার কমবে ৩০ শতাংশ

■ নিজামুল হক

পরিবেশবান্ধব বায়ো-অর্গানিক সার উদ্ভাবন করেছেন বাংলাদেশ ধান গবেষণা ইনস্টিটিউটের মৃত্তিকা বিজ্ঞান বিভাগের বিজ্ঞানীরা। দশটি ব্যাকটেরিয়া, কাঁচা শাক-সবজির অবশিষ্টাংশ, রান্না ঘরের পচনশীল বর্জ্য, রক ফসফেট (শতকরা ৫ ভাগ) ও কার্বন উপাদান বায়োচার (শতকরা ১৫ ভাগ) মিশিয়ে তারা এ সার উদ্ভাবন করেছেন।

বিজ্ঞানীরা জানিয়েছেন, ধান চাষে ব্যবহারযোগ্য এ সার মাঠ পর্যায়ে আউশ, বোরো ও আমন মৌসুমে পরীক্ষা করা হয়েছে। আউশ মৌসুম এ সার হেক্টর প্রতি এক টন এবং বোরো ও আমন মৌসুমে দুই টন ব্যবহার করতে হয়।

পরীক্ষার ফলাফল বিশ্লেষণ করে বিজ্ঞানীরা জানিয়েছেন, এটি ব্যবহার করলে ধানের জমিতে পূর্ণ মাত্রার টিএসপি ও শতকরা প্রায় ৩০ ভাগ কম ইউরিয়া সার দিলেও ফলনে কোনো ঘাটতি হয় না। তথ্য অনুযায়ী, ইউরিয়া ও টিএসপি সারের জন্য সরকারকে প্রতি বছর বিপুল অর্থ ভর্তুকি দিতে হয়। তা ছাড়া ইউরিয়া ও টিএসপি উৎপাদনে পরিবেশের জন্য ক্ষতিকর গ্রিন হাউস গ্যাস তৈরি হয়। প্রতি কেজি ইউরিয়া ও টিএসপি উৎপাদনে প্রায় সাড়ে ছয় কেজি কার্বন-ডাই-অক্সাইড বাতাসে যুক্ত হয়। পৃষ্ঠা ১৯ কলাম ৩

ধান আবাদে পরিবেশ

প্রথম পৃষ্ঠার পর

বিজ্ঞানীরা জানিয়েছেন, টিএসপি অথবা ডিএপি সার তৈরির প্রধান কাঁচামাল হচ্ছে রক ফসফেট, যার বাজার মূল্য কেজি প্রতি মাত্র পাঁচ টাকা। রক ফসফেট সহজে দ্রবীভূত হয় না বিধায় এটিকে ধানসহ বিভিন্ন স্বল্প মেয়াদি ফসলে সরাসরি ব্যবহার করা যায় না। মাটির অন্যতম উপাদান ফসফেট দ্রবণকারী ব্যাকটেরিয়া খুব সহজেই রক ফসফেটকে স্বল্প সময়ে দ্রবীভূত করে উদ্ভিদের গ্রহণযোগ্য করে তোলে।

উদ্ভাবিত বায়ো-অর্গানিক সার ধান চাষে ব্যবহারে একদিকে যেমন শতকরা ৩০ ভাগ ইউরিয়া সার ও পূর্ণ মাত্রার টিএসপি সারের ব্যবহার কমাবে, অন্যদিকে কাঁচা বাজারসহ রান্নাঘরের বর্জ্য দ্রব্যকে ধান চাষে জৈব সার রূপে ব্যবহার করে পরিবেশ দূষণ কমিয়ে আনা যাবে। পাশাপাশি মাটিতে জৈব পদার্থ যোগ করে মাটির স্বাস্থ্য সুরক্ষায় উল্লেখযোগ্য ভূমিকা রাখবে।

উদ্ভাবিত সারটির সঙ্গে শতকরা ১৫ ভাগ বায়োচার আছে বিধায় মাটিতে সরাসরি কার্বন যোগ করে মাটির গুণাগুণ বৃদ্ধি করবে। গবেষণালব্ধ ফলাফলে দেখা গেছে, বছরের পর বছর ক্রমাগত শুধু রাসায়নিক সার ব্যবহারের ফলে মাটিতে বসবাসকারী বাতাসের নাইট্রোজেন সংযোজনকারী ফসফেট, দ্রাবক ও অন্যান্য উপকারী ব্যাকটেরিয়ার সংখ্যা কমে যাচ্ছে। মাটির এসব অনুজীব উদ্ভিদের জন্য প্রয়োজনীয় পুষ্টি উপাদান সরবরাহে উল্লেখযোগ্য ভূমিকা রাখে। ব্রিতে এ প্রযুক্তির উদ্ভাবক ড. উম্মে আমিনুন নাহার, ড. যতীশ চন্দ্র বিশ্বাস, মো: ইমরান উল্লাহ সরকার ও আফসানা জাহান।

ধান গবেষণা ইনস্টিটিউটের মৃত্তিকা বিজ্ঞান বিভাগের প্রধান এবং মুখ্য বৈজ্ঞানিক কর্মকর্তা ড. যতীশ চন্দ্র বিশ্বাস বলেন, আমাদের দেশের বেশিরভাগ জমিতে জৈব পদার্থের পরিমাণ ১ শতাংশেরও নিচে। তাই এ ধরনের সার ব্যবহারের ফলে দীর্ঘমেয়াদি ইতিবাচক প্রভাব পড়বে। এ ছাড়া কৃষকদের উৎপাদন খরচ কমবে।

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Bio-organic fertilizer for rice production

A new technology to reduce Urea and TSP use

M A Kashem

Soil science division of Bangladesh Rice Research Institute has developed an environment friendly Bio-organic fertilizer for growing rice, using decomposable vegetable waste from household and kacha bazar, rock phosphate (5%), and rice husk biochar (15%) along with a consortium of locally isolated 10 beneficial bacteria. Use of this biofertilizer will reduce 30% use of urea and eliminate 100% use of TSP fertilizer for rice production. The efficacy of this bio-organic fertilizer on rice has been tested at field level in Boro, Aus and T. Aman seasons. The application rate of this bio-organic fertilizer for rice cultivation in Aus season is 1ton/ha while in T. Aman and Boro it is 2 ton/ha. The study result showed that there is no significant yield reduction by applying this bio-organic fertilizer while it reduces the use of 100% dose of TSP and 30% of urea fertilizers. Every year the government has to subsidize a huge amount of money for urea and TSP fertilizers.

A partial view of the BRRI developed new bio-organic fertilizer.

Moreover, fertilizer production and uses emits greenhouse gases. Research results revealed that production of one kg urea and 1 kg TSP fertilizer emits about 6 kg CO_2 in the air. The main raw material of TSP and DAP production is rock phosphate, which is cheap and market price is only five taka per kg. Rock phosphate cannot be used directly in cultivation of rice and other short duration crops because of its low solubility. A group of environment friendly bacteria living in the soil known as phosphate solubilizing bacteria can solubilize rock phosphate rapidly and make it available to the plants. Application of this bio-organic fertilizer will reduce 30% use of urea and full dose of TSP in rice cultivation and also reduce the environment pollution using the wastes from household kitchen and vegetable market places as organic matter in rice cultivation.

Moreover, it will maintain soil health by adding organic matter and beneficial microbes to the soil. This biofertilizer will increase soil quality by adding carbon directly in soil as it contains 15% biochar, a sort of carbon. Research findings indicate that the populations of free living nitrogen fixing bacteria, phosphate solubilizing bacteria as well as other beneficial bacteria are decreasing due to long term sole application of chemical fertilizers. These bacteria play vital role in supplying nutrients to the plant and soil nutrient cycling. Application of this bio-organic fertilizer will increase these beneficial bacteria population in the soil.

This environment friendly technology will reduce the urea and TSP production and use or import cost as well as contribute largely in increasing rice yield with sustaining soil health. Dr Umme Aminun Naher, Dr Jatish Chandra Biswas, Md Imran Ullah Sarkar and Afsana Jahan all are scientist from Soil Science Division, BRRI have played their role in developing this environment friendly technology.

The writer is a Technical editor and head of PPRD at Bangladesh Rice Research Institute.

নীতির প্রশ্নে আপোসহীন দৈনিক জনকণ্ঠ

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কৃষিতে জৈব সার

খাদ্যশস্য বিশেষ করে ধান উৎপাদনে বাংলাদেশ এখন প্রায় স্বয়ংসম্পূর্ণ। প্রায় ১৭ কোটি জনসংখ্যা অধ্যুষিত একটি দেশের জন্য এটি নিঃসন্দেহে ইতিবাচক অগ্রগতি। এবার বর্ষা মৌসুম শুরু না হতেই আকস্মিক অতিবৃষ্টি, পাহাড়ী ঢলে সুনামগঞ্জসহ সুবিস্তৃত হাওড় এলাকা এবং চলনবিল অঞ্চল তলিয়ে যায়। ফলে ধানের ব্যাপক ক্ষতি হয়। এরপর নতুন করে মিয়ানমার থেকে দলে দলে রোহিঙ্গা শরণার্থীর ঢল আসায় বেড়ে যায় চালের দাম। ফলে জরুরী পরিস্থিতি মোকাবেলায় চাল আমদানি করতে হয়।

বর্তমানে বাজারে নতুন ধান আসতে থাকায় চালের দর কমতির দিকে। তবে এর আগে বাংলাদেশ উদ্বৃত্ত খাদ্যশস্য রফতানিও করেছে। অনেকক্ষেত্রে ফড়িয়া ও মধ্যস্বত্বভোগীদের দৌরাত্ম্যে কৃষক এমনকি ধানের ন্যায্যমূল্যও পাননি। এত বিপুল পরিমাণ ধান-চাল উৎপাদনের কৃতিত্ব কৃষকের পাশাপাশি অবশ্যই বাংলাদেশ ধান গবেষণা ইনস্টিটিউটের বিজ্ঞানীদের। তারা নিত্যনতুন গবেষণা করে উন্নতমানের উচ্চ ফলনশীল ধানের বীজ, খরা ও লবণসহিষ্ণু ধান, ভিটামিন এ যুক্ত ধানবীজ ইত্যাদি উদ্ভাবন করেছেন, যা বিপ্লব এনে দিয়েছে কৃষিক্ষেত্রে। এর ফলে উত্তরাঞ্চলে খরা মৌসুমে মঙ্গা পরিস্থিতি এবং দক্ষিণাঞ্চলে লবণাক্ত জমিতে সম্ভব হচ্ছে ধান উৎপাদন।

> দেশ এখন খাদ্য উৎপাদনে শুধু স্বয়ংসম্পূর্ণ নয়; বরং উদ্বৃত্ত খাদ্যশস্যে ভরপুর। দেশে সাড়ে ১২ লাখ টন খাদ্য উদ্বৃত্ত থাকে জনসাধারণের দৈনন্দিন খাদ্য চাহিদা মিটিয়েও

এবার ধান গবেষণা ইনস্টিটিউটের বিজ্ঞানীরা উদ্ভাবন করেছেন বায়োঅর্গানিক সার। যা জৈব সার নামে অধিক পরিচিত। পরিবেশবান্ধব এই সার একাধিক ব্যাকটেরিয়া, রান্নাঘরের বর্জ্য, আরও কিছু উপাদান মিশিয়ে তৈরি। এই সার ব্যবহার করা হলে কৃষিতে ইউরিয়ার ব্যবহার কমবে ৩০ শতাংশ এবং টিএসপির ব্যবহার কমে আসবে অনেকাংশে। অথচ ফলনের কোন ঘাটতি হবে না। উল্লেখ্য, বর্তমানে চাষাবাদে ব্যবহৃত ইউরিয়া ও টিএসপি সারের জন্য সরকারকে প্রতিবছর বিপুল পরিমাণ ভর্তুকি দিতে হয়। অনেকক্ষেত্রে আমদানি করে মেটাতে হয় স্থানীয় চাহিদা।

রাসায়নিক সার বাতাসে প্রচুর পরিমাণে কার্বন নিঃসরণ করে বিধায় আদৌ পরিবেশবান্ধব নয়। এতে জমির জৈব উপাদনসহ উৎপাদন শক্তিও কমে। সে অবস্থায় বায়োঅর্গানিক বা জৈব সার বর্তমানে ব্যবহৃত ইউরিয়া ও টিএসপির একটি ভাল বিকল্প হতে পারে নিঃসন্দেহে।

দেশ এখন খাদ্য উৎপাদনে শুধু স্বয়ংসম্পূর্ণ নয়; বরং উদ্বৃত্ত খাদ্যশস্যে ভরপুর। দেশে সাড়ে ১২ লাখ টন খাদ্য উদ্বৃত্ত থাকে জনসাধারণের দৈনন্দিন খাদ্য চাহিদা মিটিয়েও। জাতীয় সংসদের গত অধিবেশনে এই তথ্য প্রকাশ করেন খাদ্যমন্ত্রী। বাংলাদেশের খাদ্যশস্য উৎপাদনে এই সাফল্যের প্রশংসা করা হয়েছে বিশ্ব খাদ্য সংস্থা ও বিশ্বব্যাংকের পক্ষ থেকে।

এসবই ডিজিটাল কৃষির অবদান। বিশ্বে চাল উৎপাদনে বাংলাদেশের অবস্থান চতুর্থ, সবজি উৎপাদনে তৃতীয়, মাছ উৎপাদনে চতুর্থ, ফল উৎপাদনে সপ্তম। উন্নতমানের প্রযুক্তি, বীজ, জৈব সার, সেচ, কীটনাশক ইত্যাদি ব্যবহার করে এ উৎপাদন আরও বাড়ানো যায়। এখন নজর দেয়া উচিত বিভিন্ন বহুমুখী খাদ্যশস্য উৎপাদন এবং সংরক্ষণে। সরকারের অন্যতম অগ্রাধিকার হলো সব মানুষের জন্য খাদ্য নিশ্চিত করা। গমের ঘাটতি এখনও আছে। এর পাশাপাশি ডাল, তেলবীজ, ডিম, মাংস, দুধ, মাছ, মসলা উৎপাদনেও ঘাটতির বিষয়টি বিবেচনায় নেয়া বাঞ্ছনীয়। মনে রাখতে হবে, শুধু ভাতে পেট ভরে বটে তবে পুষ্টি ও সুস্বাস্থ্য নিশ্চিত হয় না। গত কয়েক বছরে শাকসবজি, ফলমূল উৎপাদন বাড়লেও মাছ, দুধ, মাংস জাতীয় খাদ্য অর্থাৎ প্রোটিনে বিপুল ঘাটতি এখনও রয়ে গেছে।

তথ্যপ্রযুক্তিভিত্তিক চাহিদা ও জোগাননির্ভর ডিজিটাল কৃষি ব্যবস্থাপনা ও বাজার ব্যবস্থা অপরিহার্য। সরকার দেশের সব খাদ্যগুদাম অনলাইনের আওতায় আনার উদ্যোগ নিয়েছে, যা প্রশংসনীয়। এর পাশাপাশি অত্যাবশ্যক অত্যাধুনিক খাদ্যগুদাম নির্মাণ ও মানসম্মত খাদ্য সংরক্ষণ ও ব্যবস্থাপনা। তা হলেই বহুমুখী খাদ্য উৎপাদন বৃদ্ধির পাশাপাশি নিশ্চিত হবে সবার জন্য খাদ্য নিরাপত্তা।

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TRUE AND IMPARTIAL

Bio-organic Fertiliser for Rice Production

A new technology to reduce urea and TSP use

SOIL science division of Bangladesh Rice Research Institute has developed an environment friendly Bio-organic fertiliser for growing rice, using decomposable vegetable waste from household and kacha bazar, rock phosphate (5%), and rice husk biochar (15%) along with a consortium of locally isolated 10 beneficial bacteria. Use of this biofertiliser will reduce 30% use of urea and eliminate 100% use of TSP fertiliser for rice production. The efficacy of this bio-organic fertiliser on rice has been tested at field level in Boro, Aus and T. Aman seasons. The application rate of this bio-organic fertiliser for rice cultivation in Aus season is 1ton/ha while in T. Aman and Boro it is 2 ton/ha.

The study result showed that there is no significant yield reduction by applying this bio-organic fertiliser while it reduces the use of 100% dose of TSP and 30% of urea fertilisers. Every year the government has to subsidise a huge amount of money for urea and TSP fertilisers. Moreover, fertiliser production and uses emits greenhouse gases. Research results revealed that production of one kg urea and 1 kg TSP fertiliser emits about 6 kg CO2 in the air. The main raw material of TSP and DAP production is rock phosphate, which is cheap and market price is only five taka per kg. Rock phosphate cannot be used directly in cultivation of rice and other short duration crops because of its low solubility. A group of environment friendly bacteria living in the soil known as phosphate solubilizing bacteria can solubilize rock phosphate rapidly and make it available to the plants. Application of this bio-organic fertiliser will reduce 30% use of urea and full dose of TSP in rice cultivation and also reduce the environment pollution using the wastes from household kitchen and vegetable market places as organic matter in rice cultivation. Moreover, it will maintain soil health by adding organic matter and beneficial microbes to the soil. This biofertiliser will increase soil quality by adding carbon directly in soil as it contains 15% biochar, a sort of carbon.

BRRI Director General Dr Md Shahjahan Kabir, BRRI Director (Research) Dr Md Ansar Ali along with the concerned scientists are visiting the experiment field of newly developed bio-organic fertiliser at BRRI premises recently.

Research findings indicate that the populations of free living nitrogen fixing bacteria, phosphate solubilizing bacteria as well as other beneficial bacteria are decreasing due to long term sole application of chemical fertilisers. These bacteria play vital role in supplying nutrients to the plant and soil nutrient cycling. Application of this bio-organic fertiliser will increase these beneficial bacteria population in the soil. This environment friendly technology will reduce the urea and TSP production and use or import cost as well as contribute largely in increasing rice yield with sustaining soil health. Dr Umme Aminun Naher, Dr Jatish Chandra Biswas, Md Imran Ullah Sarkar and Afsana Jahan all of whom are scientists from Soil Science Division, BRRI have played their role in developing this environment friendly technology.

A partial view of the BRRI developed new bio-organic fertiliser

M A Kashem, Technical Editor and Head, PPRD, BRRI.

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যায়যায়দিন
১৯৮৪ থেকে

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ধান চাষে বায়ো-অর্গানিক ফার্টিলাইজার

রাসায়নিক সার সাশ্রয়ী বায়ো-অর্গানিক সার উদ্ভাবন করতে সক্ষম হয়েছেন বাংলাদেশ ধান গবেষণা ইনস্টিটিউটের (ব্রি) মৃত্তিকা বিজ্ঞান বিভাগের বিজ্ঞানীরা। রাসায়নিক সার ব্যবহারে উৎপাদন বাড়লেও এর দীর্ঘমেয়াদি প্রভাবে মাটির উৎপাদনক্ষমতা হ্রাস পায়। তাই কৃষি বিজ্ঞানীরা মাটির গুণাগুণ ঠিক রাখতে রাসায়নিক সারের ব্যবহার কমানো ও জৈব সারের ব্যবহার বাড়ানোর ওপর গুরুত্ব দেন। আদর্শ ও উর্বর মাটিতে শতকরা ৫ শতাংশ জৈব পদার্থ থাকার কথা থাকলেও বাংলাদেশের মাটিতে বর্তমানে জৈব পদার্থের পরিমাণ ১ শতাংশ বা তারও কম। তাই মাটির জৈব পদার্থের পরিমাণ কিভাবে ২% বা তারও বেশি পর্যায়ে উন্নীত করা যায় এ ব্যাপারে বাস্তবসম্মত গবেষণা কার্যক্রম হাতে নিয়েছেন ব্রির মৃত্তিকা বিজ্ঞান বিভাগের বিজ্ঞানীরা। এ জন্য ইতিমধ্যে তারা গৃহস্থালীর আবর্জনা সংগ্রহ ও রিসাইক্লিং করে বায়ো-অর্গানিক সার ও কম্পোস্ট সার তৈরির পদক্ষেপ গ্রহণ করেছেন। মৃত্তিকা বিজ্ঞান বিভাগ কর্তৃক উদ্ভাবিত বায়ো-অর্গানিক ফার্টিলাইজার মাঠ পর্যায়ে দ্রুত সম্প্রসারণ ও উপযোগিতা যাচাইয়ের পাশাপাশি কৃষক পর্যায়ে এই সার সহজলভ্য করতে উদ্যোক্তা সৃষ্টির লক্ষ্যে কাজ করে যাচ্ছেন ব্রির মৃত্তিকা বিজ্ঞান বিভাগের বিজ্ঞানীরা।

জানা গেছে, ব্রি নতুন উদ্ভাবিত এবং ধান চাষে ব্যবহারযোগ্য বায়ো-অর্গানিক ফার্টিলাইজার এরই মধ্যে মাঠপর্যায়ে আউশ, বোরো ও আমন মৌসুমে পরীক্ষামূলকভাবে ব্যবহার করা হয়েছে। আউশ মৌসুমে এ সার হেক্টরপ্রতি এক টন এবং বোরো ও আমন মৌসুমে দুই টন হারে ব্যবহার করা হয়। ফলাফলে দেখা গেছে, এ সার ব্যবহার করলে ধানের জমিতে টিএসপি পূর্ণমাত্রায় ও ইউরিয়া শতকরা প্রায় ৩০ ভাগ সাশ্রয় করা যায়। এটি ব্যবহার করলে ফলনেও কোনো তারতম্য হয় না। এই সার উদ্ভাবক দলের একজন অন্যতম বিজ্ঞানী ও মৃত্তিকা বিজ্ঞান বিভাগের প্রধান বৈজ্ঞানিক কর্মকর্তা ড. উম্মে আমিনুন নাহার জানান, পরিবেশবান্ধব ১০টি ব্যাকটেরিয়া, বাজারের কাঁচা শাক সবজির অবশিষ্টাংশ, রান্না ঘরের পচনশীল বর্জ্য পদার্থ, রক ফসফেট (শতকরা ৫ ভাগ) ও বায়োচার (শতকরা ১৫ ভাগ) মিশিয়ে বায়ো-অর্গানিক সার উদ্ভাবন করেছেন। বায়ো-অর্গানিক সারের উদ্ভাবক দলের অন্য সদস্যরা হলেন, ড. যতীশ চন্দ্র বিশ্বাস, মো. ইমরান উল্লাহ সরকার ও আফসানা জাহান।

মাঠ পরীক্ষা পর্যবেক্ষণ করছেন ব্রির মহাপরিচালক ও পরিচালক গবেষণাসহ উদ্ভাবক দলের সদস্যরা (ইনসেটে), বায়ো-অর্গানিক সার নিয়ে কাজ করছেন এক বিজ্ঞানী

ইউরিয়া ও টিএসপি সারের জন্য সরকারকে প্রতি বছরে বিপুল পরিমাণে অর্থ ভর্তুকি দিতে হয়। তাছাড়া সার উৎপাদনে পরিবেশের জন্য ক্ষতিকারক গ্রিনহাউস গ্যাস তৈরি হয়। গবেষণায় দেখা গেছে, প্রতি কেজি ইউরিয়া ও টিএসপি উৎপাদনে প্রায় সাড়ে ছয় কেজি কার্বন-ডাই-অক্সাইড বাতাসে যুক্ত হয়। টিএসপি অথবা ডিএপি সার তৈরীর প্রধান কাঁচামাল হচ্ছে রক ফসফেট, যার বাজার মূল্য কেজি প্রতি মাত্র পাঁচ টাকা। রক ফসফেট সহজে দ্রবীভূত হয় না বিধায় এটিকে ধানসহ বিভিন্ন স্বল্প মেয়াদি ফসলে সরাসরি ব্যবহার করা যায় না। মাটিতে বসবাসকারী এক শ্রেণির পরিবেশবান্ধব ব্যাকটেরিয়া যা ফসফেট দ্রবণকারী ব্যাকটেরিয়া নামে পরিচিত এবং খুব সহজেই রক ফসফেটকে স্বল্প সময়ে দ্রবীভূত করে উদ্ভিদের গ্রহণযোগ্য করে তোলে। তাই বিজ্ঞানীদের উদ্ভাবিত সার অর্থ সাশ্রয়ের পাশাপাশি পরিবেশ রক্ষায় ভূমিকা রাখবে।

উদ্ভাবিত বায়ো-অর্গানিক সার ধান চাষে ব্যবহারে একদিকে যেমন শতকরা ৩০ ভাগ ইউরিয়া সার ও পূর্ণ মাত্রার টিএসপি সারের ব্যবহার কমাবে, অন্যদিকে কাঁচা বাজারসহ রান্নাঘরের বর্জ্য দ্রব্যকে ধান চাষে জৈব সার রূপে ব্যবহার করে পরিবেশ দূষণ কমিয়ে আনা যাবে। তদুপরি মাটিতে জৈব পদার্থ যোগ করে মাটির স্বাস্থ্য বজায় রাখতে উল্লেখযোগ্য ভূমিকা রাখবে। এই উদ্ভাবিত সারটির সঙ্গে শতকরা ১৫ ভাগ বায়োচার আছে বিধায় মাটিতে সরাসরি কার্বন যোগ করে মাটির গুণাগুণ বৃদ্ধি করবে।

❑ এম এ মোমিন

Bio-organic fertilizer: A green technology to improve soil health and rice yield

Umme Aminun Naher, Md. Imran Ullah Sarkar, Afsana Jahan, Jatish C. Biswas, Md. Rafiqul Islam
Bangladesh Rice Research Institute, Gazipur-1701

Introduction

Rice production in Bangladesh is chemical fertilizer and pesticide based, which impaired soil quality, ecosystem biodiversity, and causes environment pollution. Loses of biodiversity is related to deterioration of soil health as nutrient cycling is the direct contribution of microbial activity. In this context, to restore and improve soil health, a biofertilizer developed and named as "Bio-organic fertilizer" with combination of vegetable waste/degradable kitchen waste (80%), rice husk biochar (15%), rock phosphate (5%) and consortium of (10) plant growth promoting bacteria. Rock phosphate (5%) was incorporated in this product, which acts as an alternate of TSP fertilizer for rice production. Application of 1-2 ton ha^{-1} improved rice yield and soil biology .

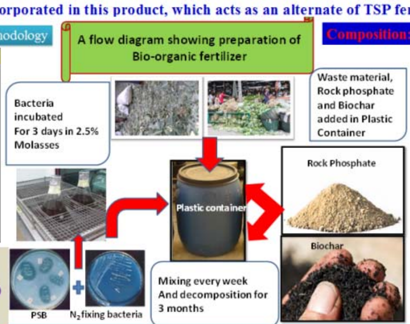
Methodology

Microorganisms added: Phosphate solubilizing bacteria are able to ensure bio-available P from rock phosphate. The beneficial bacteria added in this biofertilizer are indigenous and isolated from favorable and unfavorable rice ecosystem (drought, saline and acid soil). The microorganisms involved in this bio-organic fertilizer are grouped as free-living N_2fixing bacteria, phosphate solubilizing bacteria (PSB) and indoleacetic acid (IAA) producing bacteria

Strain ID	Location	%IAA	%N	%P
B mycoides	Lalmonirhat	0.01	0.07	0.04
Proteus sp	Lalmonirhat	0.01	0.13	0.01
B cereus	Lalmonirhat	0.36	0.08	0.11
B subtilis	Komolganj	0.01	0.08	0.04
B pumilus	Patuakhali	0.03	0.04	0.08
Paenibacillus sp	Gazipur	0.03	0.07	0.11
Paenibacillus polymyxa	Gazipur	0.40	0.14	0.05
Bacillus sp	Kuakata	0.35	0.07	0.10
Bacillus sp	Komolganj	0.02	0.06	0.08
Bacillus sp	Gazipur	0.30	0.10	0.11

Special Feature of the Bio-organic fertilizer:
- Reduced 25-30%use of urea (934 t N_2O Y^{-1})
- Eliminate 100% use of TSP (5.39 m. t CO_2 Y^{-1})
- Add C to the soil (15% Biochar)
- Increase rice yield by 0.5-1 t ha^{-1}
- Improve soil biology

A flow diagram showing preparation of Bio-organic fertilizer



Application rate: Aus :1 t ha^{-1} T. Aman: 2 t ha^{-1} Boro: 2 t ha^{-1}
Applied during last land preparation

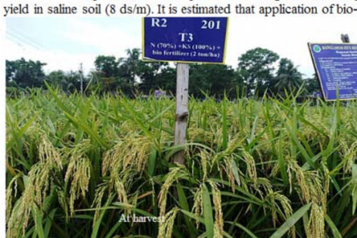
Composition:

Parameters	content
color	Dark grey
Physical condition	Non granular
Odor	No foul odor
pH	7.2
OC(%)	25
N (%)	1.4
P (%)	1.04
K (%)	0.91
S (%)	0.35
Zn (%)	0.03
Cu (%)	0.006
Pb (ppm)	0.01
Cd (ppm)	0.67
Cr (ppm)	27.0
As (ppm)	11.50
N_2 fixing Bacteria(cfu g^{-1})	6×10^8
PSB(cfu g^{-1})	8×10^8

Bio-organic fertilizer

Result & Discussion:

The developed biofertilizer being tested since the year 2016 to 2018 in Aus, Aman and Boro seasons at BRRI farm Gazipur, BRRI R/S Rajshahi, BRRI R/S Barishal, BRRI R/S Cumilla, and at farmers' fields of Rajshahi, Pirojpur, Kuakata, Kishoreganj, Barguna and Dacope. The results of the research stations and farmers field proved that application of bio-organic fertilizer in Aus, T. Aman and Boro season fulfill 25-30% urea and 100% TSP fertilizer requirement for rice production and gave statistically similar or higher grain yield (0.5-1 t ha^{-1}) compared to full (100%) chemical fertilizer and improved soil biology. Bio-organic fertilizer improved rice yield in saline soil (8 ds/m). It is estimated that application of bio-organic fertilizer did not increase additional cost.



Effect of bio-organic fertilizer on paddy yield at BRRI,Gazipur, Cumilla and Barishal (variety BRRI dhan58)

Treat	Gazipur	Cumilla	Barishal
	Grain Yield(t/ha)		
T_1	4.69 b	6.58b	5.84a
T_2	6.04 a	8.31ab	6.33a
T_3	5.88 a	8.67a	6.0a
T_4	2.81 c	3.29c	3.23b

T_1=BoF (2 t/ha), T_2= NPKS (100%) ,T_3= BoF+ NKS (75%) , T_4= Control, NPKS kg/ha@ 67-10-41-10

Effect of Bio-organic on plant growth and yield at BRRI, R/S Rajshahi (variety BRRI dhan71)

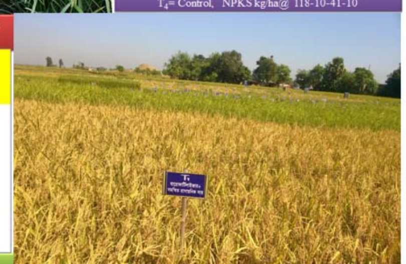
Treat	Tiller/m^2	Panicle /m^2	Grain Yield (t/ha)	Straw yield (t/ha)
T_1	184 b	179 b	3.87 b	5.26 ab
T_2	206 ab	198 ab	4.09 b	5.54 a
T_3	218 a	212 a	4.44 a	5.55 a
T_4	182 b	179 b	3.55 c	4.79 b

T_1=BoF(2 t/ha), T_2= NPKS (100%), T_3= BoF+ NKS (30%) T_4= Control, NPKS kg/ha@ 118-10-41-10

Effect of bio-organic fertilizer on plant growth and yield at Farmer's field Location: Kuakata, Amtoli, Najirpur

Farmers' name	Location	Variety	Treat	Tiller/m^2	Panicle/ m^2	Grain Yield (t/ha)	Straw yield (t/ha)
Shahidul Islam	Kuakata	BRRI dhan49	T_1	256	248	3.85	4.37
			T_2	305	247	3.49	4.92
Elias Mir	Nazirpur	BRRI dhan52	T_1	336	252	4.63	5.82
			T_2	350	300	4.49	5.61
Md. Al-Amin	Barguna	BRRI dhan54	T_1	352	339	5.66	4.72
			T_2	327	309	5.14	5.55
Kabul Sheikh	Nazirpur	BRRI dhan52	T_1	-	-	4.52	-
			T_2	-	-	3.89	-

T_1=BoF+70% (NKS) , T_2= Farmers' practice (100% chemical fertilizer)

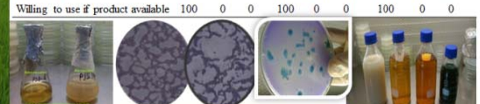


Effect of Bio-organic on plant growth and yield at Farmer's field Location: Katiadi, Kishoreganj (T. Aman 2017)

Farmers' name	Variety	Treat	Tiller/ m^2	Panicle/m^2	Grain Yield (t/ha)	Straw yield (t/ha)
Samsuddin	BRRI dhan71	T_1	342	283	4.66	5.49
		T_2	323	222	4.38	4.68
Jewel Rana	BRRI dhan75	T_1	172	133	3.08	4.07
		T_2	161	127	2.77	3.77
Robi Mian	BRRI dhan75	T_1	273	236	3.42	3.32
		T_2	288	239	3.09	2.81
Abul Kalam	BRRI dhan49	T_1	284	281	4.53	5.33
		T_2	290	278	4.66	5.56

T_1=BoF+70% (NKS) , T_2= Farmers' practice (100% chemical fertilizer)

Farmers Opinion (%)	Rajshahi			Pirojpur			Kishoreganj		
	Good	fair	Bad	Good	fair	Bad	Good	fair	Bad
Odor	100	0	0	100	0	0	100	0	0
User friendly	98	2	0	100	0	0	95	0	0
Yield benefit	100	0	0	100	0	0	100	0	0
Willing to use if product available	100	0	0	100	0	0	100	0	0



Effect of Bio-organic fertilizer on soil biology (Barishal R/S)

Treatment	Total bacteria	Fungus	Actinomycetes	Free living N_2-fixing bacteria	Phosphate solubilizing bacteria
T_1	1.96×10^7	3.29×10^3 a	4.35×10^2	2.03×10^4	2.35×10^4
T_2	1.77×10^7	1.53×10^3 b	3.55×10^2	1.87×10^4	5.10×10^3
T_3	1.80×10^7	1.68×10^3 b	4.26×10^2	2.09×10^4	1.13×10^4
T_4	1.18×10^7	9.31×10^2 b	1.86×10^2	8.37×10^3	3.34×10^3
Initial population	1.54×10^7	2.73×10^3	1.82×10^2	1.55×10^4	3.82×10^3

T_1=BoF (2 t/ha), T_2= NPKS (100%) ,T_3= BoF+ NKS (75%) , T_4= Control, NPKS kg/ha@ 67-10-41-10

Performance of Bio-organic fertilizer over chemical fertilizer for Boro rice (BRRI dhan67) cultivation at Amtoli , Barguna and Dacope , Khulna at Boro, 2018

Location	Amtoli, Borguna				Dacope, Khulna			
Management	Plant height (cm)	Panicle/ m^2	Filled grain/panicle	Yield (t/ha)	Plant height (cm)	Panicle/ m^2	Filled grain/panicle	Yield (t/ha)
Bio-organic fertilizer + 70% NK	99.5	365	110	5.5	102.4	410	114	6.71
Full chemical fertilizer (N-P-K-S @ 140-20-80-10 kg ha^{-1})	100.5	335	94	4.5	101.3	340	115	5.82

Conclusion:

Bio-organic fertilizer is a eco-friendly biofertilizer formulated for rice production. It is tested in different agro-ecological zones of Bangladesh. Study result proved that application of 1-2 t/ha^{-1} biofertilizer improved crop yield and soil biology. It is also applicable in the saline soil.

Acknowledgement
- Bangladesh Rice Research Institute
- PIU-BARC, NATP phase-2 (PID 707)
- Organization for Women in Science for the Developing World

Some pictures:

Pictures: Reaserch Station trial at Boro 2017-18

Pictures: Field visit by Director Research, Extension personal and Head BRRI R/S Rajshahi

Pictures: Harvest at Najirpur, Pirojpur