Challenges for Nutrient Management in Bangladesh

by

M S Islam*

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* Soil Scientist and Former Director General, BARI, Bangladesh

Introduction to Bangladesh

- **Bangladesh - the largest deltaic floodplain in the world**
- **Total area – 147570 km^2 ;**
  Area covered by rivers and estuaries: 88892 km^2
  Agro Ecological Zone (AEZ) – 30
- **Population – 150 million ;**
  Population density 974/km^2 ;
  Annual growth rate 1.54%

Introduction to Bangladesh

- **Economy - agriculture based**
- **Total cultivated land- 8.2 million hectares; Cropping intensity-185%**
- **The country is food deficit area for a long time**

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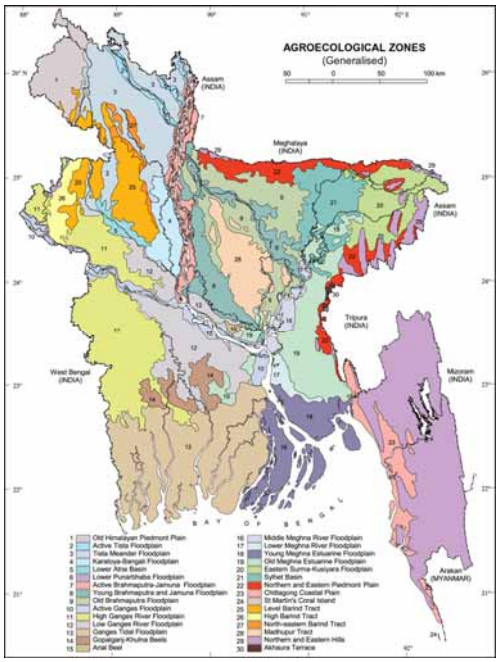

The challenges

The major challenges of nutrient management include:

- **-timely supply and availability of fertilizers at the doorstep of the farmers**
- **-recommendation based on soil and crop requirements**
- **-use of organic manure, biofertilizers and plant growth regulators**
- **-strengthening soil testing services and**
- **-maintenance of soil health.**

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- Fertilizer supplies plant nutrient and is considered one of the key inputs for increasing crop yields
- Its contribution to crop production is about 50-60%.

Fertilizer use

Year	Urea	TSP	DAP	SSP	MoP	Gypsum	Ammonium sulphate	Magnesium sulphate	Zinc sulphate	NPKS	Total
2001-02	2247	425	127	127	222	96	15	10	13	13	329
2002-03	2239	405	112	130	250	120	30	10	14	10	3320
2003-04	2324	361	90	148	240	140	15	10	14	13	3355
2004-05	2523	420	140	170	260	135	16	10	14	26	3714
2005-06	2451	436	145	130	290	104	10	10	20	99	3695
2006-07	2600	340	115	125	122	26	25	12	20	160	3543
2007-08	2515	325	122	115	230	72	26	15	25	120	3565
2008-09	2850	500	200	100	400	150	25	20	50	150	44.45

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Fertilizer Distribution System

- Marketing, promotion and distribution of almost all fertilizers except urea in the country are now controlled by the private sectors.
- The transition from government to private sector passed through various phases of experimentation and took about 40 years to complete.

Present System

- All fertilizer requirements of the country such as TSP, DAP, MoP and urea (about 40-50%), etc are met through import by the private companies.
- Out of total requirement of urea (2.52 million tons during 2007-08) only 1.45 million tons and small amount of TSP (50,000 tons) as well as SSP (0.10 million ton) were produced within the country

Fertilizer Subsidy

- The government in consultation with Bangladesh Fertilizer Association (BFA) decided to provide 55% subsidy on these fertilizers.
- During 2004-05 and 2005-06 the government provided US$ 37.31 and 53.04 millions, respectively as subsidy for the phosphate and potash fertilizers.

Present Soil Fertility Status

Nitrogen

- Total nitrogen content of Bangladesh soils range from 0.032% in the Shallow Red-Brown Terrace Soils to 0.20% in Peat Soils.
- The approximate values of total nitrogen used to interpret soil test values are:
  - Low: up to 0.090-0.181%
  - Medium: 0.181-0.270%
  - Optimum: 0.271-0.360%

Nitrogen

The main reasons for N deficiency are due to:

- intense decomposition of organic matter
- rapid removal of mineralized products under high leaching conditions and
- crop removal.

N deficiency in rice during early growth stage

N deficiency in maize

Grain and straw yield of BRRI dhan28 and BRRI dhan29 as affected by different nitrogen rates.

N rate	BRRI dhan28		BRRI dhan29	
	Grain yield (kg/ha)	Straw yield (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)
N_0	2160d	2605d	2600f	2858f
N_{40}	3640c	3598c	3862e	4053e
N_{80}	4710b	5140b	6000c	5620d
N_{100}	5600a	5753a	6640b	6465c
N_{120}	5712a	6095a	7230a	7468ab
N_{140}	5642a	6000a	7300a	7648a
N_{160}	5340a	6063a	7130ab	7740a
N_{200}	4039c	6525ab	5400d	7843b
CV%	6.55	7.10	5.88	6.11

Phosphorus

- In medium and heavy textured soils, the available P contents:
  - up to 7.50 μg g^{-1} soil is interpreted as low
  - 15.1-22.5 μg g^{-1} soil as medium and
  - 22.51-30.0 μg g^{-1} soil as optimum for upland crops

Phosphorus

- For wetland rice, soil P contents of
  - 6.0-12.0 μg g^{-1}soil are considered as low
  - 12.1-18.0 μg g^{-1} soil as medium and
  - 18.0-24.0 μg g^{-1} soil as optimum.

Phosphorus

- The critical level of P by the Olsen method, which is extensively used for rice, has been considered as 8.0 μg g^{-1}soil in Bangladesh so long

Phosphorus

The response of hybrid maize to phosphorus fertilization

Phosphate added (kg/ha)	Yield (t/ha)	
	Grain	Stalk
0	4.28	5.35
30	6.34	7.93
60	7.45	9.23
90	7.39	9.31
CV (%)	8.88	8.88

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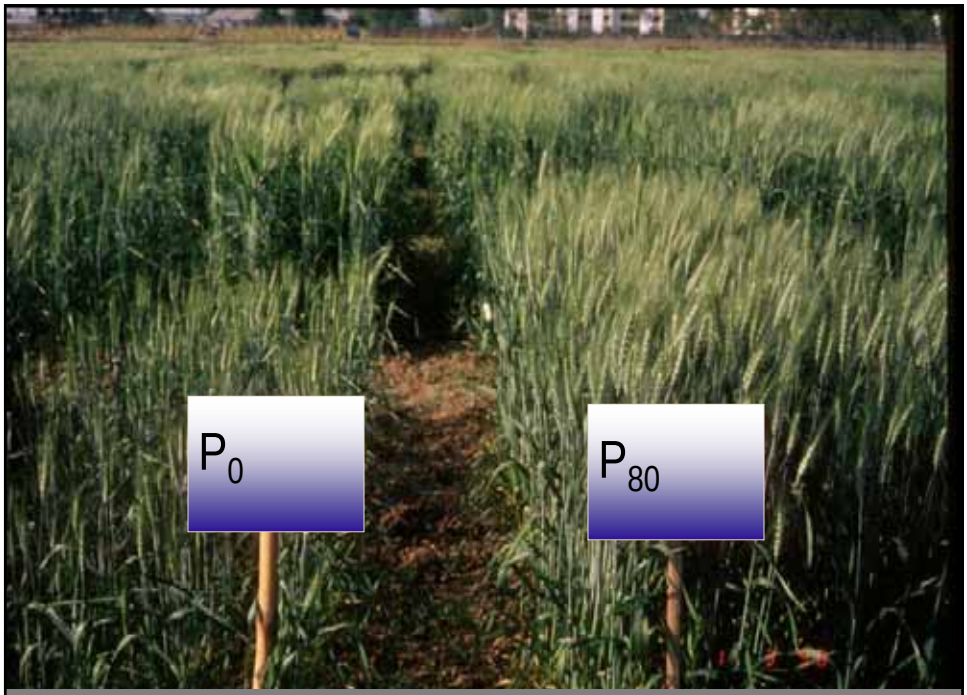
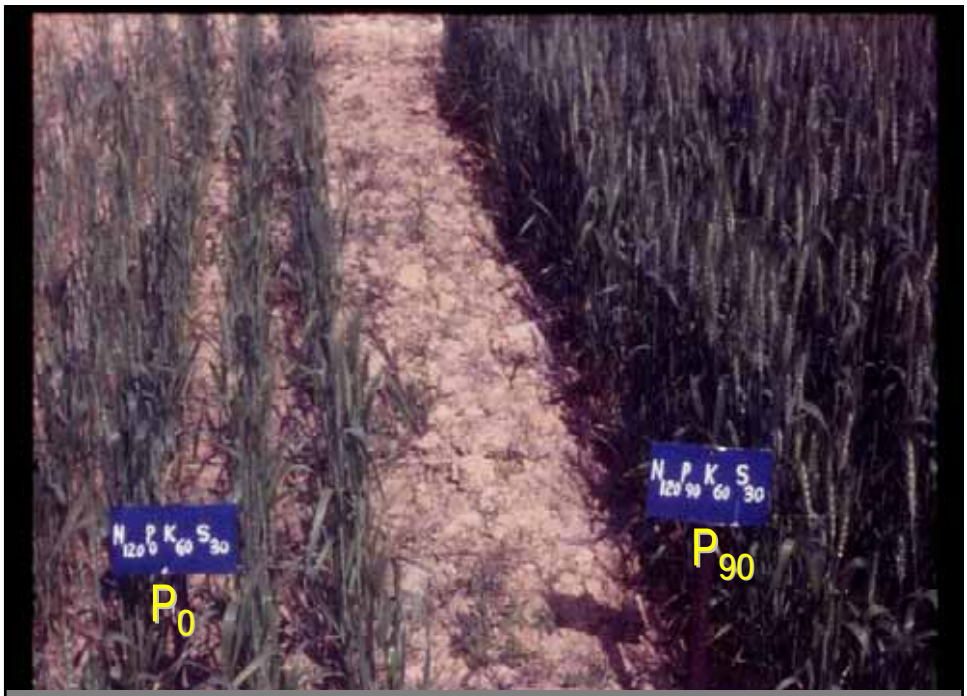

P_0
P_{80}


$N_{120}P_0K_{60}S_{30}$
P_0
$N_{120}P_{90}K_{60}S_{30}$
P_{90}

P deficiency in mustard (*Campestris*)

P deficiency in maize

P deficiency in mungbean

Potassium

- The crop intensification with high yielding and hybrid varieties has shown widespread deficiency of potassium in Bangladesh soils on potato, sweet potato and other root crops, sugarcane, fruit, onion, garlic, fiber crops and HYV cereals.

Potassium

- It has been recorded that a 5 ton/ha rice crop will remove more than 110 kg K which is to be made available to plants in less than 3 months time and many of our old and highly weathered soils may not have potential to supply K at this rate.

- One-ton wheat/ha or 2-ton rice/ha can be obtained from soils where K would be a limiting factor continuously without K fertilizers

Effect of K rates on the grain yield of boro varieties at BRRI farm (BRRI[3])

K rate (kg/ha)	Grain yield (t/ha)			
	BRRI dhan36	BRRI dhan45	Hybrid-EH_1	Hybrid-EH_2
Ko	1.86	2.86	3.64	3.08
K20	5.01	5.70	6.40	6.48
K40	5.58	5.04	5.62	6.22
K60	5.90	5.93	5.92	6.00
K80	5.87	6.09	6.27	6.46
LSD (0.05)	0.64			
CV (%)	7.3			

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K deficiency in rice

K deficiency in potato

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K deficiency in sunflower

Sulphur

- In the past very little attention was paid to this nutrient until 1977 when sulphur deficiency in wetland rice was first detected at the Bangladesh Rice Research Institute (BRRI) farm and on nearby farmers' fields
- Variable amount of available S ranging from as low as 2 μg g^{-1} soil to as high as 75 μg g^{-1} soil has been reported.

Sulphur

- The use of high analysis fertilizers such as urea, triple super phosphate, muriate of potash and diammonium phosphate, cultivation of modern varieties, increasing cropping intensities and limited application of organic manure have all contributed to the intensification of the S deficiency problem in Bangladesh soils
- The critical level of sulphur for Bangladesh soils has been determined as 10 μg g^{-1} soil.

S deficiency in rice

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S deficiency in mustard (*Campestris*)

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S deficiency in ground nut

S deficiency in ground nut

S deficiency in pomelo

S deficiency in *Sesbania*

Calcium and Magnesium

- Most of our soils have adequate Ca and Mg saturation on the exchange surface
- The critical levels for these two nutrients are as 2.00 and 0.5 meq100g $^{-1}$

Calcium and Magnesium

- Magnesium deficiency problems have been observed on potato, cotton, sugarcane and tea grown on these soils and added Mg has brought about an appreciable increase in yields.
- Although Ca is also inadequate in these soils, applications of TSP and gypsum to supply P and S satisfactorily meet Ca demand of crops, thus correcting Ca deficiency properly

Ca deficiency in tomato

Ca deficiency in cauliflower

Mg deficiency in maize

Mg deficiency in potato

Mg deficiency in red amaranth

Mg deficiency in cucumber

Mg deficiency in cotton

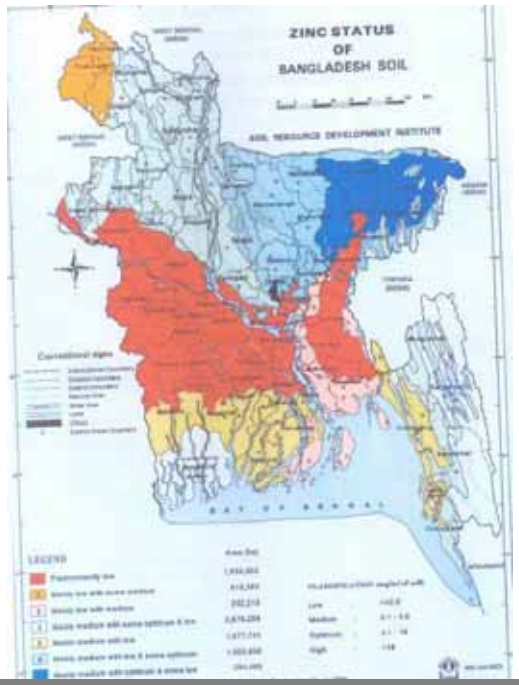
Mg deficiency in tea

Zinc

- The critical levels of available soil zinc content as established by different extracting procedures are 1 ppm for light textured soils and 2 ppm for heavy and calcareous soils.

Zinc

- **The critical level of Zn in rice plant tissue is generally considered as 20 ppm.**
- **Yield responses of rice to zinc fertilization have been well documented in different soils of Bangladesh where zinc contents were below the critical level.**



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Zn deficiency in rice

Zn deficiency in maize

Boron

- The available boron content of the major soils of Bangladesh varies between 0.1 and 1.9 ppm.
- But most of the light textured soils of Rangpur, Dinajpur and terrace soils of Gazipur and hill soils of Srimangal contain low level of available B (0.1-0.3 ppm).

Boron

- The critical level of available soil boron used to interpret the soil test result is 0.2 ppm.
- However, Studies showed that sterility problems in wheat, chickpea and mustard grown on sandy soils of Rangpur were significantly improved by the application of boron.

Boron

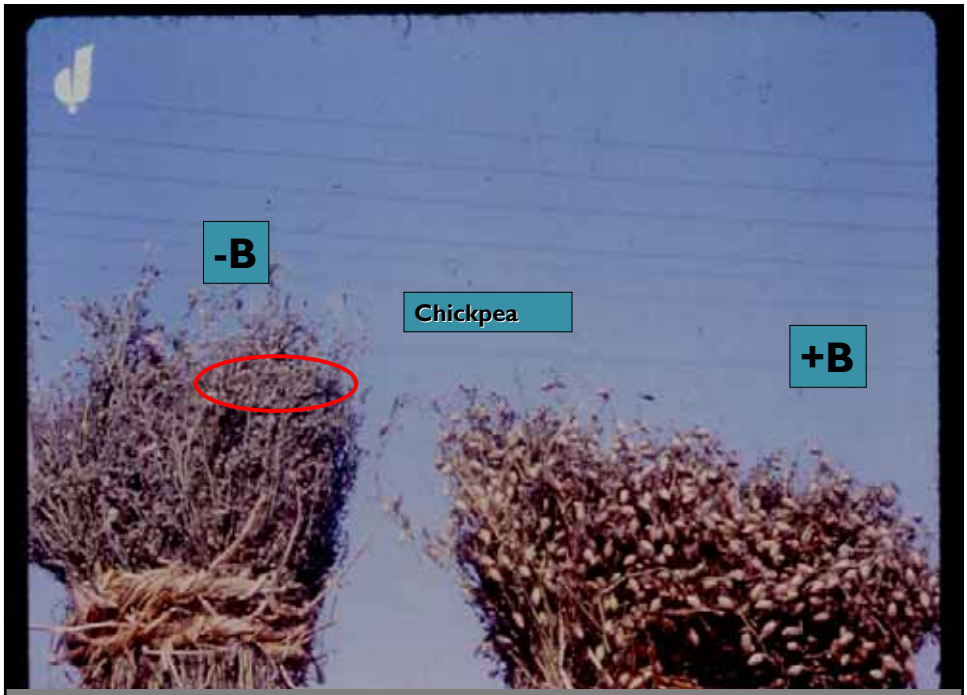
- Wheat yield after boron treatment was increased by more than 50% and was contributed by increased number of grain per spike
- Yields of vegetables like cauliflower, cabbage, broccoli and tomato were found to increase (14-52%) due to B fertilization.

B deficiency in wheat

B deficiency in maize

B deficiency in mustard (*Napus*)

B deficiency in chickpea



B deficiency in papaya

B deficiency in cauliflower

Other Micronutrients

- Other micronutrients like Fe, Mn, Cu, Mo and Cl have attracted less attention in Bangladesh agriculture.
- Generally they are seldom needed to be applied in crop production in most soils

Other Micronutrients

- However, recently Cu and Mn application in Calcareous Soils have appeared to be beneficial for higher yield in some field trials.
- Recent studies have also indicated that Mo deficiency is widespread in cabbage and legumes like groundnut acid soils.

Other Micronutrients

- Deficiency of Cl has been detected in coconut and betel nut plants.
- But proper potassium fertilization with muriate of potash prevents the occurrence of Cl deficiency problems in most cases.
- Iron is the only micronutrient present in available form abundantly in Bangladesh soils.

Mo deficiency in cabbage

Mo deficiency in cauliflower

Present Supply and Availability Situations

- The Ministry of Agriculture, in consultation with the Department of Agricultural Extension fixes up monthly as well as annual requirement of fertilizers.
- Besides demand requirement, the Ministry also makes a total exercise on production, import and price fixation.

Domestic Production

- In Bangladesh urea, TSP and SSP are produced in the local industries, which can partly meet the total demand of the country.
- About 60,000 phosphogypsum is produced as a byproduct from TSP factory.
- At present there are six urea and one TSP factories in the country.

Domestic Production

- Natural gas provides the feedstock for urea production.
- Bangladesh Chemical Industries Corporation (BCIC) is responsible for operation of all fertilizer factories in the country.
- All these fertilizer factories can produce 1.70 million, tons of urea, 12000 tons of ammonium sulphate, 50,000 tons of TSP, 0.10 million ton of DAP and 0.10 million tons of SSP

Domestic Production

Year	Production (tons)			
	Urea	TSP	SSP	DAP
2001-02	1546000	68000	120000	-
2002-03	2057000	65600	136400	-
2003-04	2164000	65000	135500	-
2004-05	2200000	65000	134000	-
2005-06	1700000	60000	100000	-
2006-07	1700000	60000	100000	100000
2007-08	1400000	50000	100000	100000
2008-09	1700000	50000	100000	100000

Fertilizer Types and Grades

- The farmers of Bangladesh use mainly single or straight fertilizers as sources of their nutrients.
- Urea, TSP, DAP, SSP and MOP are the widely used straight fertilizers.
- Among them, urea shares about 66%, TSP 11%, SSP 4.3%, DAP 4.3% and MOP 9% of the total fertilizer use.

Fertilizer Types and Grades

- The government of Bangladesh has recommended 6 crop specific grades of mixed or blended fertilizers for balanced application of nutrient elements in the crop fields. These grades are:

1. NPKS (8-20-14-5) for HYV Rice
2. NPKS (10-24-17-6) for HYV Rice
3. NPKS (10-15-10-4) for Sugarcane
4. NPKS (14-22-15-6) for Sugarcane
5. NPKS (12-16-22-6.5) for Wheat and other Rabi crops
6. NPKS (12-15-20-6) for Wheat and other Rabi crops

Present challenges of nutrient management

- According to current statistics, the farmers of Bangladesh use 191 kg nutrients (N: 143 kg, P_2O_5: 27 kg, K_2O: 17 kg and S +Zn + B + others: 4 kg) ha/year from chemical fertilizers, while the estimated removal is around 250 -350 kg/ha.

- From organic and natural sources about 50-70 kg nutrients are added to the soil system every year.

Present challenges of nutrient management

- Annual depletion of nutrients (NPKS) in many areas under intensive cultivation ranges between 150 and 250 kg ha^{-1} yr^{-1}.

- One nutrient balance study made by DAE-SFFP[4] from a typical Boro- Fallow -T. Aman cropping pattern (10 t grain yields) shows that negative balance of 78 kg N and 41 kg K in a hectare of land are occurring every year (Table 6).

Effect of Grameen Shakti Jaibo sar (organic fertilizer) on the yield of tomato

Nutrient dynamics	N (kg/ha)	P (kg/ha)	K (kg/ha)
Nutrient uptake cropping pattern	180	27	180
Leaching losses from: Soil Fertilizer	12 17	- -	6 -
Erosion	12	2	12
Gaseous losses: organic	24	-	-
N fertilizer	68		
Total Output	313	29	198
Fertilizer	170	25	75
Organic manure (5t/ha)	20	12	24
Incorporated crop residue	25	3	25
Non symbiotic fixation	10	-	-
Atmospheric fixation	8	1	2
Sedimentation/weathering	-	2	10
Irrigation water	2	6	21
Total Input	235	49	157
Balance	-78	20	-41

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Adoption of Integrated Nutrient Management System (IPNS)

The major objectives of IPNS may be conceptualized as follows:

- **To build up an optimum combination of nutrient resources based on soil test values for nutrient supply for their efficient utilization**
- **To avoid over-exploitation of nutrient resources**
- **To maintain long-term soil fertility and to prevent soil degradation**

Adoption of Integrated Nutrient Management System (IPNS)

Treatment	Yield(t/ha)		%Increase over control	
	Gazipur	Faridpur	Gazipur	Faridpur
T_1:100%RD	64.7ab	73.3ab	183.77	153.63
T_2: 75%RD	56.9c	66.5cd	149.56	130.10
T_3: 50%RD	46.3d	54.9e	103.07	89.97
T4: 75%RD+CD@5 t/ha	63.9ab	71.2a-d	180.26	146.37
T_5: 50%RD+CD@10 t/ha	58.8c	66.8bcd	157.89	131.14
T_6: 75%RD+CD bioslurry@5 t/ha*	65.1ab	72.9abc	185.53	152.25
T_7: 50%RD+CD bioslurry@10 t/ha*	61.8abc	66.6bcd	171.05	130.45
T_8: 75%RD+PM@3 t/ha	64.6ab	70.4a-d	183.33	143.60
T_9: 50%RD+PM@6 t/ha	60.4bc	66.9d	164.91	131.49
T_{10}: 75%RD+PL bioslurry@3 t/ha*	66.6a	75.0a	192.11	159.52
T_{11}: 50%RD+PL bioslurry@6 t/ha*	60.6bc	68.0bcd	165.79	135.29
T_{12}:Control (native fertility)	22.8e	28.9f	-	-
SE(±)	1.57	2.02		
CV (%)	4.72	5.38		

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Adoption of Integrated Nutrient Management System (IPNS)

Yield of vegetables in Tomato-Okra-Indian spinach cropping pattern as influenced by integrated use of chemical fertilizers and organic manure at homestead, Tangail during 2005-06

Treatments	Chemical fertilizers	Tomato		Okra		Indian spinach		Yield(t/ha)			Tomato equivalent yield(t/ha)
		PM	CD	PM	CD	PM	CD	Tomato	Okra	Indian spinach	
		t/ha									
T_1	100%RD	0	0	0	0	0	0	64.2ab	9.7ab	36.2a	102.7
T_2	75%RD	10	0	5	0	0	0	66.4a	20.8a	34.7ab	104.5
T_3	75%RD	0	10	0	5	0	0	60.2b	18.8abc	32.5abc	95.76
T_4	50%RD	10	0	5	0	0	0	58.7b	17.3bcd	30.8bc	91.78
T_5	50%RD	0	0	0	10	0	0	53.3c	15.4cd	28.4c	73.1
CV (%)								6.5	9.8	7.3	

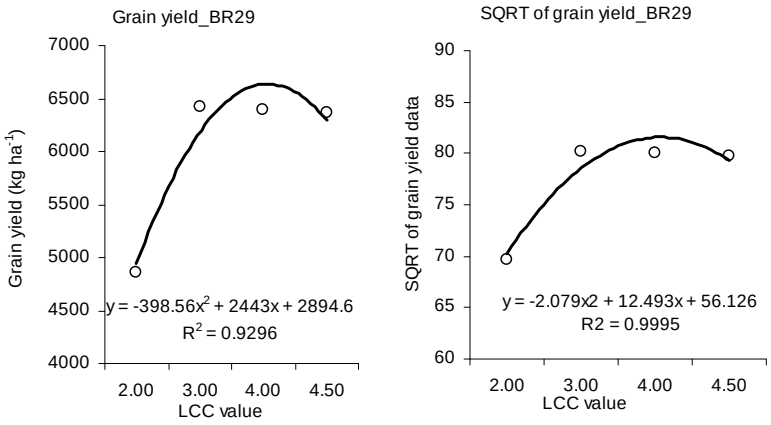
Fertilizer Recommendation

- Fertilizer recommendation for single crops and cropping patterns are usually made by following the guidelines clearly stated in "The National Fertilizer Recommendation Guide"
- Upazila Soil Use Guide published and updated by SRDI from time to time is also a useful guide for site-specific fertilizer recommendation

Fertilizer Recommendation

- For high yield goal fertilizer recommendation, one should have site-specific information on nutrient status of soils as well as the crops.
- If the site-specific information on the soils is not available, moderate yield target may be fixed and the information available about agro ecological region in the guide may be used to find out the fertilizer doses.

Fig.1. Grain yield (kg ha^{-1}) and Square root (SQRT) of grain yield data of BRRI dhan29 as affected by different LCC value based N treatments, BRRI, Gazipur, 2002.



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Use of Bio-fertilizers

- **BARI and BINA have been experimenting with different crop specific biofertilizers since 1980.**
- **Some of the biofertilizers proved useful for chickpea, lentil, mungbean, groundnut and soybean which is quite evident from Table .**
- **Their contribution to yield increases range from 5 to15% where the native population of the microbes is low.**

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Effect of rhizobial inoculums and chemical fertilizers on the seed yield of lentil (BARI[1]).

Treatment	Yield (t/ha)	
	2006-07	2007-08
$N_{24}P_{22}K_{42}S_{20}Zn_5$	1.77c	1.75b
$N_{50}P_{22}K_{42}S_{20}Zn_5$	1.94b	1.65c
$P_{22}K_{42}S_{20}Zn_5$+Inoculum	2.22a	1.86a
Farmer's practice ($N_{20}P_{12}K_{17}$)	1.73c	1.56d
CV (%)	4.5	10

Use of Plant Growth Regulators

The use of plant growth regulators is still at the initial stage.

About 20 PGRs have so far been standardized for their use on horticultural and field crops.

Use of Plant Growth Regulators (PGR)

Yield and seed quality of chili (Capsicum annum L.) as affected by different growth regulators.

Treatments	No. of fruits/pl	Fruit yield/pl (gm)	Germination (%)	Seedling vigor
T0: distilled water	71.0 d	146.6 d	65.0 d	275.5 d
T1: 10ppm Naa	136.3 a	277.8 a	92.0 a	589.1 a
T2: 50 ppm Naa	91.3 c	176.4 c	82.0 bc	522.5 ab
T3: 100 ppm Ethophone	107.7 b	221.1 b	67.0 ab	518.8 ab
T4: 500 ppm Ethophone	112.3 b	206.0 bc	79.0 c	409.5 bc
T5: 1000 ppm KNap	104.3 b	202.0 bc	78.0 c	254.1 d
T6: 5000 ppm KNap	103.7 b	189.4 c	79.0 c	358.6 cd
LSD(0.05)	10.19	29.65	7.14	129.9
CV(%)	5.61	8.35	5.05	13.73

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Soil Testing Services

- **Soil testing services in Bangladesh is weak and not satisfactory up to the standard**
- **SRDI and the soil laboratories at the NARS institutes provide soil-testing services to the farmers at limited scale**
- **The analysis serves as basis for recommendations on the application of fertilizers and soil amendments such as lime for acidic soils**

Liming

- **Although Bangladesh is a small country, she has great diversity of soils.**
- **Very strongly acidic soils have been identified from acid sulphate and brown hill areas.**
- **Red soils of Madhupur and Old Himalayan Piedmont plain soils in northwestern part of Bangladesh have also been rated as strongly acidic.**
- **Because of the increasing cropping intensity and fertilizer use in the above soils during the last two decades, the acidity has gone up unexpectedly.**
- **For every 100 kg use of urea, 74 kg calcium carbonate is needed to reduce the acidity.**

The response of maize to liming in Old Himalyan Piedmont Plain Soils

Lime applied (t/ha)	Yield (t/ha)			
	Lalmonirhat location		Patgram location	
	Grain	Stalk	Grain	Stalk
0	6.29b	7.87b	6.46b	-
1	-	-	7.45a	-
2	8.35a	10.44a	7.92	-
3	-	-	7.52a	-
CV (%)	7.65	7.66	10.69	

Future Nutrient management Challenges

- **There exists tremendous opportunities to build a poverty and hunger free Bangladesh if the fertilizer use technology developed by the NARS institutes is disseminated.**
- **The soils of Bangladesh are continuously being depleted because of increasing cropping intensity.**
- **If appropriate measures are not taken to correct the deficiencies, the soil resources will be degraded.**
- **Under such situations, production program of agricultural crops to a level that will ensure food security will be jeopardized.**
- **Environmental pollution due to fertilizer use would be minimum if proper methods of soil fertility management are adopted.**

Short-term actions

- Application of balanced fertilizers to crops /cropping patterns
- Site specific fertilizer application through soil testing/leaf color chart
- Application of USG and UMG to increase efficiency of nitrogen
- Sufficient application of potash fertilizers to arrest it's mining
- Strengthening activities of soil fertility and fertilizer management project
- Production, marketing and distribution of compost, farmyard manure, vermicompost, bioslurry, etc
- Increasing uses of mixed and DAP fertilizers
- Undertaking action program for quality control of fertilizers
- Introduction of pulse crops/sesbania in between two rice crops
- Introduction of jute in wheat-fellow-rice pattern.

Long-term actions

- Strengthening Integrated Soil and Fertilizer Management Program
- Strengthening Coordinated Soil Test Response Studies
- Strengthening IPNS Approach and establishment of IPNS school for the farmers

Conclusion

- **Timely supply and availability of fertilizers at reasonable prices can only ensure proper nutrient management that is very much needed for our depleted soils for optimum supply of nutrients for successful crop production and maintenance of soil health.**

- **The use efficiency of the chemical fertilizers are low and unsatisfactory because of imbalanced or under use/sometimes over use resulting in huge wastage which the country cannot afford.**

Conclusion

- **Therefore, the practice of balanced fertilization should receive top priority to sustain/increase crop productivity when food security is so crucial for poverty stricken people, when the country is facing challenges of increasing population and shrinking natural resources and also when there exists big gap between research and farmer's yield.**

Thank You

Soybean seeds innoculated with Rhizobium

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.