WELCOME

To the presentation of

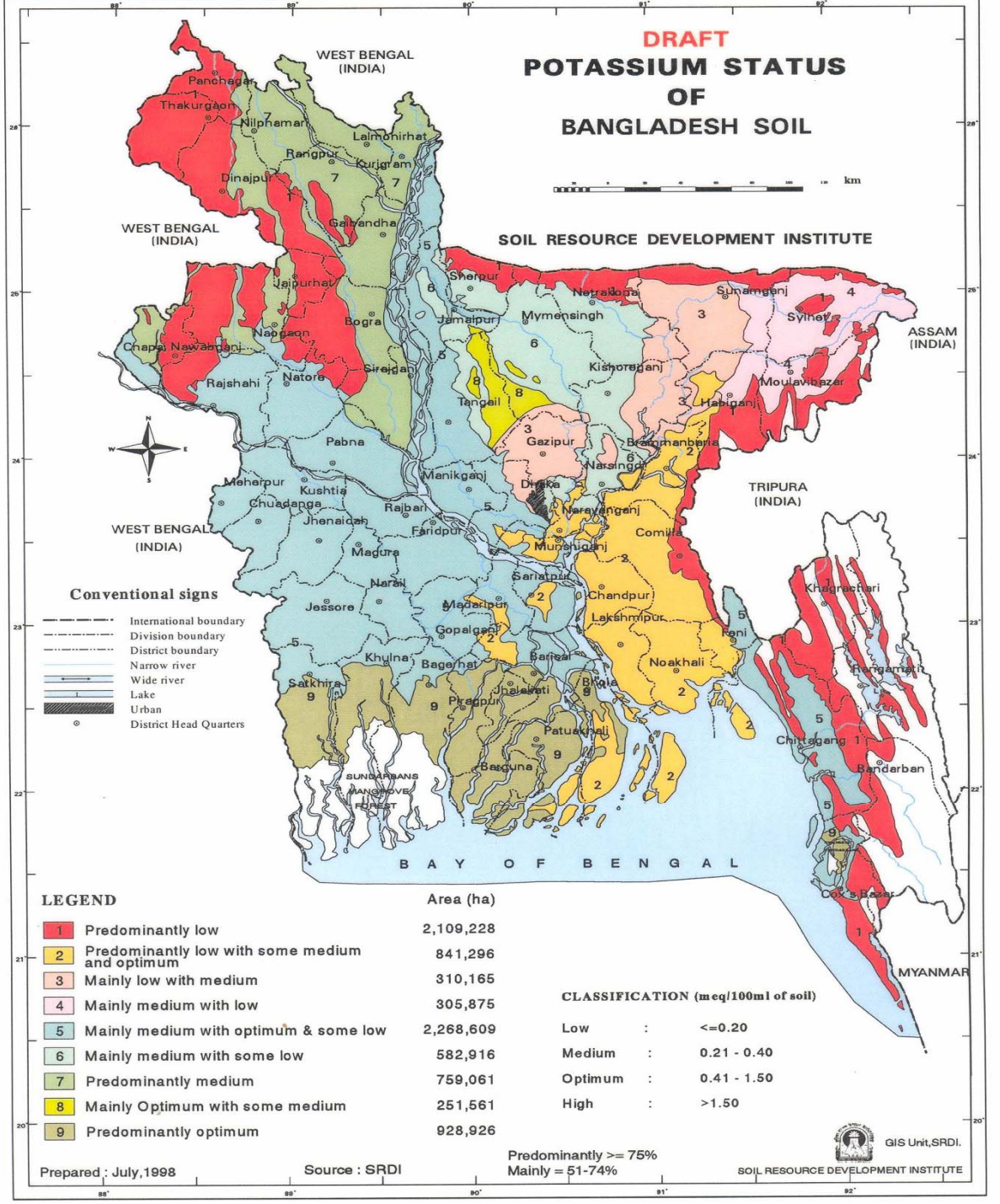
Potassium fertilization in rice-rice and rice-wheat cropping system in Bangladesh

Bangladesh Rice Research Institute

Background

- Potassium (K) is a major plant nutrient and its requirement for rice is quite high, even greater than that of nitrogen (N).
- The K reserve of any soil is certainly limited, and no soil can supply K to crops adequately for an indefinite period of time.
- Intensive cropping and use of modern rice varieties for high yield caused heavy depletion of K in soils particularly in the absence of K application.

- A negative K balance even up to 60 kg/ha applied K level with diminishing magnitude was observed in a study of BRRI.
- Recent study indicated that about 60% cultivable land of Bangladesh is deficient in N, P and K.
- Potassium deficiency is predominant in the North Western region of Bangladesh.
- Light texture soils of these areas has low exchangeable K and farmers also use low amount of K fertilizer.


DRAFT
POTASSIUM STATUS
OF
BANGLADESH SOIL
SOIL RESOURCE DEVELOPMENT INSTITUTE
WEST BENGAL (INDIA)
ASSAM (INDIA)
TRIPURA (INDIA)
MYANMAR
BAY OF BENGAL
SUNDARBANS MANGROVE FOREST
Panchagar
Thakurgaon
Nilphamari
Lalmonirhat
Rangpur
Kurigram
Dinajpur
Gaibandha
Joypurhat
Bogra
Naogaon
Chapai Nawabganj
Rajshahi
Natore
Sirajgan
Sherpur
Jamalpur
Mymensingh
Netrakona
Sunamganj
Sylhet
Kishoreganj
Moulavibazar
Habiganj
Tangail
Gazipur
Brahmanbaria
Narsingdi
Dhaka
Manikganj
Pabna
Meherpur
Kushtia
Chuadanga
Rajbari
Jhenaidah
Faridpur
Magura
Madaripur
Shariatpur
Narayanganj
Comilla
Munshiganj
Narail
Jessore
Gopalganj
Khulna
Bagerhat
Barisal
Satkhira
Jhalakati
Pirojpur
Patuakhali
Barguna
Bhola
Noakhali
Laksmipur
Feni
Chandpur
Khagrachari
Rangamati
Chittagong
Bandarban
Cox's Bazar
km
Conventional signs
International boundary
Division boundary
District boundary
Narrow river
Wide river
Lake
Urban
District Head Quarters
LEGEND
Area (ha)
1 Predominantly low 2,109,228
2 Predominantly low with some medium and optimum 841,296
3 Mainly low with medium 310,165
4 Mainly medium with low 305,875
5 Mainly medium with optimum & some low 2,268,609
6 Mainly medium with some low 582,916
7 Predominantly medium 759,061
8 Mainly Optimum with some medium 251,561
9 Predominantly optimum 928,926
CLASSIFICATION (meq/100ml of soil)
Low : <=0.20
Medium : 0.21 - 0.40
Optimum : 0.41 - 1.50
High : >1.50
Predominantly >= 75%
Mainly = 51-74%
Prepared : July,1998
Source : SRDI
GIS Unit,SRDI.
SOIL RESOURCE DEVELOPMENT INSTITUTE

- As the pressure to grow more food from the same piece of land increases, the soils come under the threat of nutrient depletion.

- Rice-wheat cropping system draws a lot of potassium from the soil and may cause heavy depletion of soil K.

- Nutrient balance study indicated a negative balance for N and K and the mining of K from Bangladesh soil is now in alarming situation. The value varied between 0 to -50 kg/ha/yr for N and –100 to –225 kg/ha/yr for K.

- **The general recommended dose of K fertilizer for MV rice in Bangladesh is 35-40 kg/ha while an average crop of rice yielding 4.0 t/ha removes at least 70 kg K/ha from the soil.**
- **There is a tremendous scope of K fertilizer application for increasing cereal crop production in Bangladesh.**

- **Potassium deficiency in rice-rice and rice-wheat cropping system has so far received limited attention.**

- **Considering these points, studies were conducted at different locations with a view to develop appropriate K-fertilizer management practices for sustainable improvement of soil health and crop production of rice-rice and rice-wheat cropping system.**

Materials and Methods

- Research trials and farmers' field demonstrations were conducted with varying combination of nutrient treatments under Boro-Fallow-T. Aman and Wheat-Fallow-T. Aman cropping pattern at different locations in Bangladesh during 2003-2007.
- The locations were at central part (Gazipur, AEZ 28, Modhupur Tract ; medium highland) and North western region of Bangladesh (AEZ 1, Old Himalayan piedmont plain; medium high land)

Initial soil characteristics of the experimental sites at Gazipur

Soil properties	Locations	
	BRRI Farm	Farmer's field
pH	6.1	4.1-5.7
OM (%)	2.02 (M)	1.23 (L)-2.56 (M)
Total N (%)	0.07 (VL)	0.08 (VL)-0.13 (L)
Available P (ppm)	10.14 (L)	2.30 (VL)-5.02 (VL)
Exch. K (meq/100g)	0.17 (M)	0.08 (L)-0.21 (M)
Available S (ppm)	6.10 (VL)	3.20 (VL)-12.90 (L)
Available Zn (ppm)	2.8 (VH)	0.47 (L)-2.8 (VH)
Texture	Clay loam	Clay loam

The Gazipur soils are clay loam in texture, low in fertility status and very strongly acidic to slightly acidic in reaction

Initial soil characteristics of the experimental sites at NW* region of Bangladesh

Soil properties	Locations	
	HSTU Farm	Farmer's field*
pH	4.70	3.60-4.05
OM (%)	1.13 (VL)	1.17 (L)-1.52 (L)
Total N (%)	0.06 (VL)	0.06 (VL)-0.08 (L)
Available P (ppm)	17.80 (M)	4.53 (VL)-28.16 (OPT.)
Exch. K (meq/100g)	0.05 (VL)	0.03 (VL)-0.09 (L)
Available S (ppm)	4.50 (VL)	2.20 (VL)-6.10 (L)
Available Zn (ppm)	1.21 (OPT.)	0.40 (L)-1.40 (OPT)
Texture	Sandy loam	Sandy loam

*Dinajpur, Thakurgaon and Panchagorh districts

The soils of the experimental field in Northwestern region are sandy loam in texture, very strongly acidic to strongly acidic in nature, very low in total nitrogen, exchangeable K and S, very low to optimum in P and low to optimum in Zn content.

- Tested cropping patterns were Boro-Fallow-T. Aman in Gazipur and Wheat-Fallow-T. Aman in NW region.

- The rice varieties used for Boro were BR3, BRRI dhan28 and BRRI dhan29 and, in T. Aman BR11, BRRI dhan31, BRRI dhan39 and BRRI dhan41.

- The wheat variety used was Shatabdi.

- The continuous omission of some fertilizer was demonstrated in a long-term soil fertility experiment at BRRI farm Gazipur.
- The experiment was initiated in 1985 and has been continued to date.
- There was a “complete” treatment consisting of the application of recommended N P K S and Zn fertilizer and other treatments “missing” the nutrient elements such as –N, -P, -K, -S and -Zn.
- In Boro 2000 the -K plots were splitted to accommodate a reverse treatment i.e. the application of K (+K, 66kg K/ha/yr.) to the plots not receiving K for the last 16 years.

- In the research trials six potassium treatments with varying doses of K viz. control (K_0), recycling of crop residues but no K fertilizer (K_{0+CR}), 33 kg K/ha (K_{33}), 50 kg K/ha (K_{50}), 66 kg K/ha (K_{66}) and farmers' K doses (K_{FP}) were tested in RCB design with 4 replications.

- Farmers' field demonstrations were established with three doses of K fertilizer such as K control (K_0), farmer's practice of K (K_{FP}) and soil test based K dose (K_{STB}).

- The soil test based flat doses of NPS and Zn was applied in all the plots.

Results and discussion

Boro-Fallow-T. Aman rice cropping pattern

- Yearly grain yield (BR3, Boro + BR11, T. Aman) with the "Complete" treatment was roughly consistent within the range of 9-10 t/ha.
- The total yield in the –K plots dropped sharply from about 10 t/ha in 1985 to 6.2 t/ha in 2000.

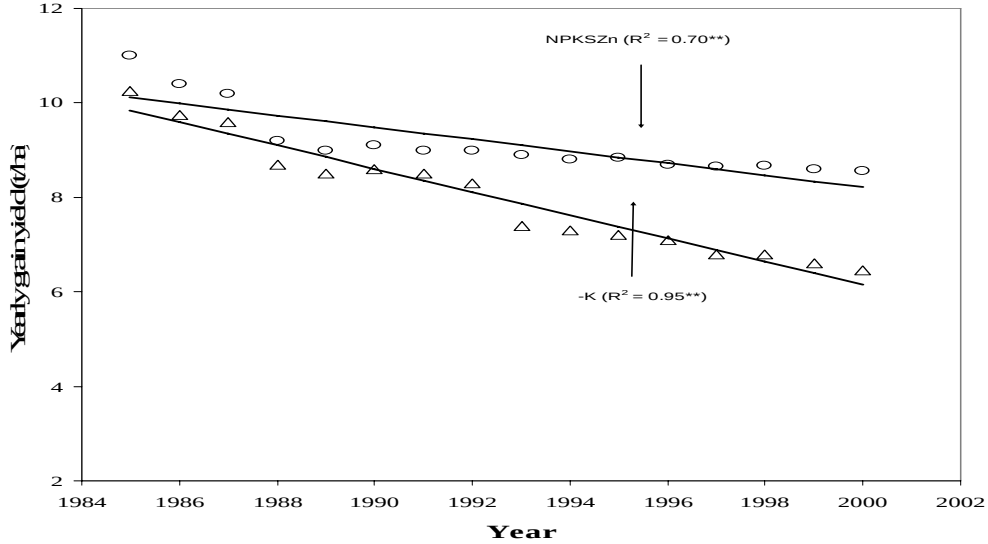


Fig.1. Total yearly grain yield of wetland MV rice under balanced and K missing fertilizer, BRRI farm, Gazipur, 1985-2000.

- The initial rice yield decrease due to omission of K was not significant. While yield gap between the balanced treatment and the –K treatment widened sharply and significantly with time.
- Over a 16-year period, the problem of especially K in the –K plots intensified severely wit time.

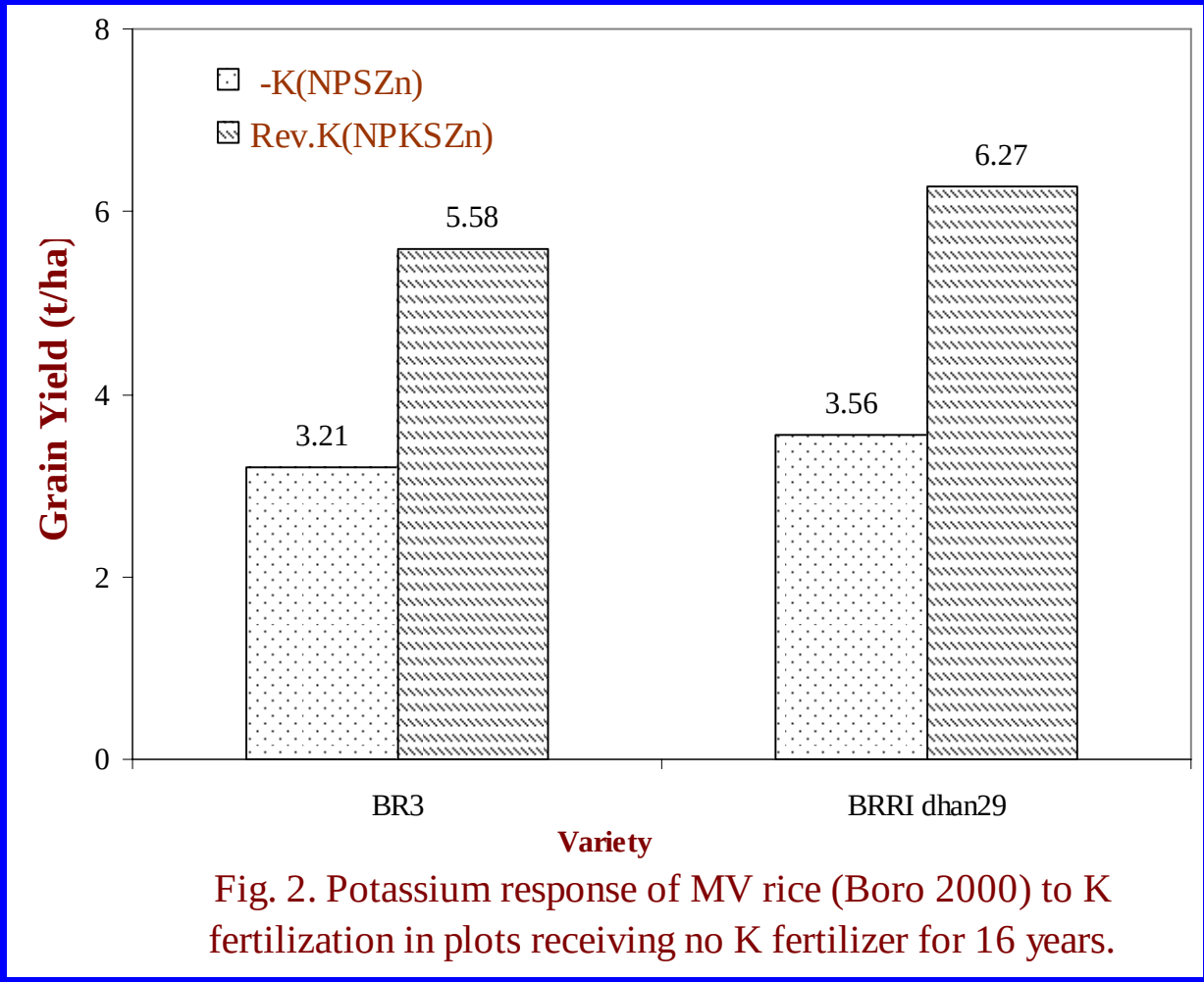


Fig. 2. Potassium response of MV rice (Boro 2000) to K fertilization in plots receiving no K fertilizer for 16 years.

The K "reverse" treatment i.e. application of K fertilizer @ 33 kg/ha in boro rice (66kg/ha/yr.) after a long period of 16 years resulted in a dramatic yield increase by about 2.5 t/ha.

- About 141 kg K/ha/yr. (2255 kg/ha in 16 years) was removed in excess of K added as fertilizer (66 kg K/ha/yr.) by two modern variety rice crops giving a grain yield of around 10 t/ha/yr.

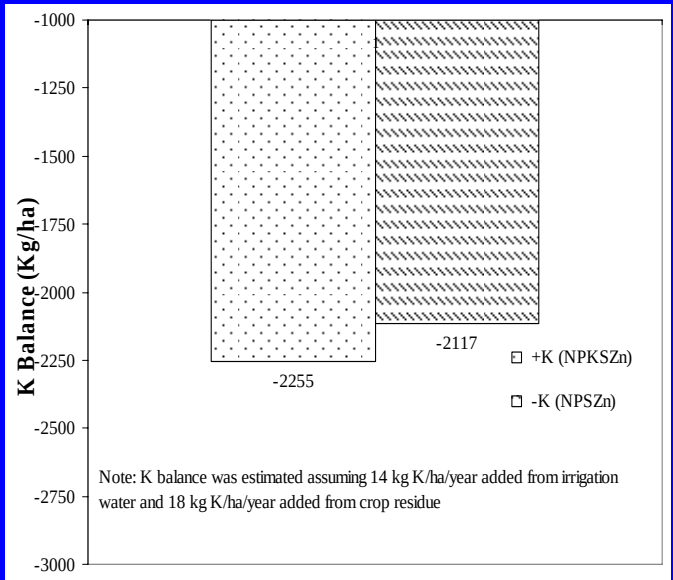


Fig.3. Long term ommission effect of K on the K balance after 16 years of the wetland MV rice under Boro- Fallow-T.Aman cropping pattern, BRRI, Gazipur, 1985-2000.

- About 132 kg K/ha/yr. (2117 kg/ha in 16 years) was removed from the soil where K was not added as fertilizer by two MV rice crops giving a grain yield of 6.2 t/ha.

- These results indicated the need for modifying the recommended K fertilizer doses for the MV rice-rice crop production system in flood free land where yearly K replenishment due to alluvial deposition does not occur.

- The application of potassium fertilizer increased grain yield of rice in any season. The increase of grain yield due to application of K fertilizer was not significant in the first crop while in the subsequent T. Aman and Boro seasons significantly higher grain yield was found with K-fertilization either from crop residues or from chemical fertilizer over control.

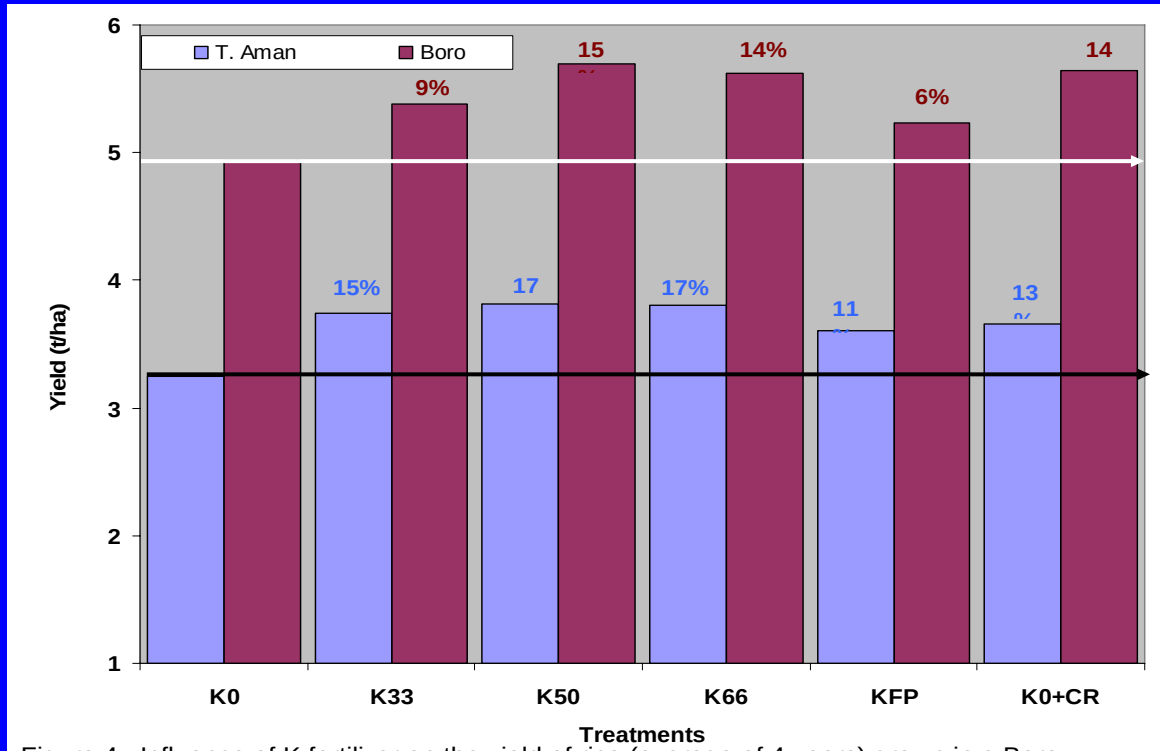


Figure 4. Influence of K fertilizer on the yield of rice (average of 4 years) grown in a Boro - Fallow - T.Aman cropping pattern, BRRI farm Gazipur 2003-07

- The grain yield was increased with the increase of applied-K doses up to 50 kg/ha in both T. Aman and Boro seasons.

- Incorporation of crop residue (rice straw) into soil @ 4.5 t/ha contributed significantly to get comparable grain yield of rice in successive crop growing seasons as produced with chemical K-fertilizer.

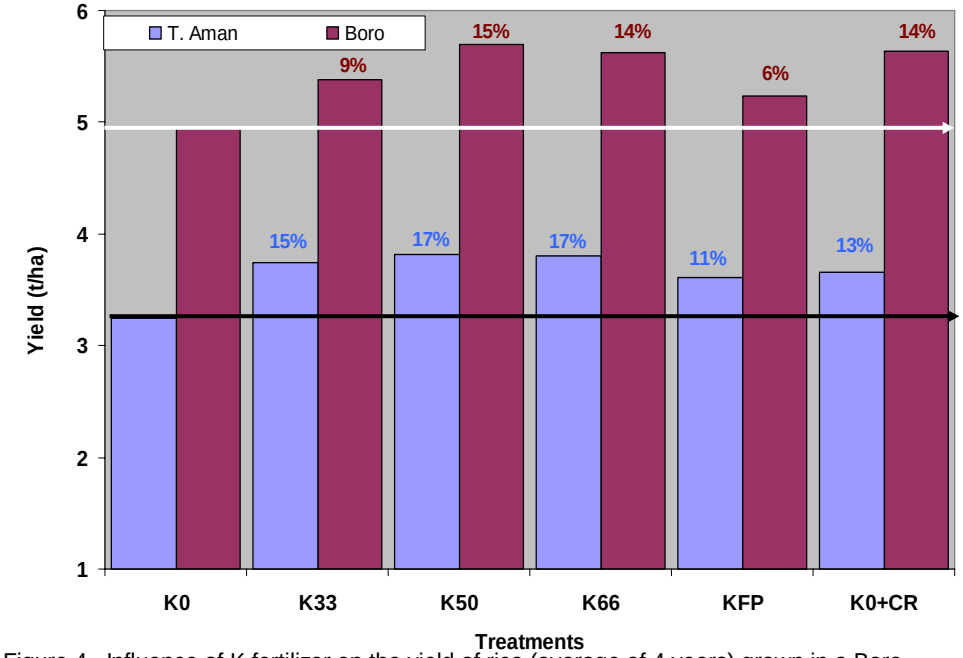


Figure 4. Influence of K fertilizer on the yield of rice (average of 4 years) grown in a Boro - Fallow - T.Aman cropping pattern, BRRI farm Gazipur 2003-07

- The average grain yield of five T. Aman and four Boro seasons indicates that the grain yield of rice increased from 11 to 17% in T. Aman and 6 to 15% in Boro season due to different doses of K applied either from chemical fertilizer or from crop residues.
- The yearly average production of rice grain was increased from 8% with farmers' fertilization practice to 16% by applying 50 kg K/ha over K control.

- In farmers' field demonstrations, K-fertilization increased the grain yield of rice in any season.
- Applied K on soil test basis (STB) produced the highest grain yield of rice followed by K_{FP} and K-control plots in both T. Aman and Boro season.

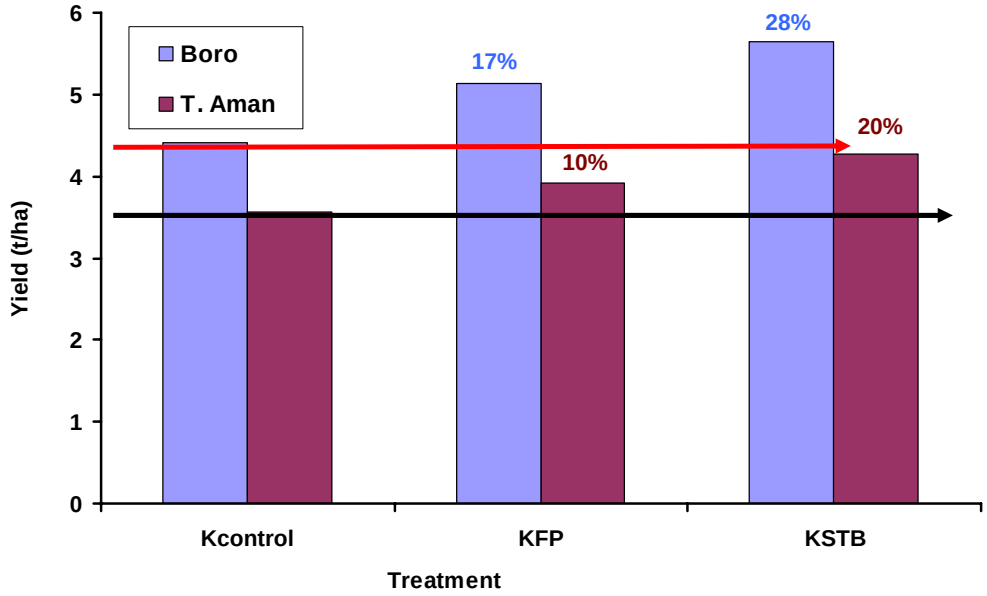


Figure 5. Influence of K fertilizer on the grain yield of rice (average of 5 trials in each season) at farmer's field grown in a Boro-Fallow-T.Aman cropping pattern,Gazipur 2003-07

- The performance of K_{STB} appeared to be superior in terms of seasonal and yearly average yield of rice grain over K_{FP}.
- The percent increase in yearly rice grain yield production estimated from K_{STB} plot was almost double (24%) to that estimated from farmers' fertilized plot (13%) over K control plot. The response of added K fertilizer to the grain yield of rice was found more prominent in dry season than that of wet season.


পটাশ সার বর্জিত
K0


কৃষকের মাত্রা


মাটি পরীক্ষার ভিত্তিতে

- **The use of K fertilizer in sandy loam soil of NW region of Bangladesh increased the grain yield of rice and wheat.**
- **The recycling of crop residues significantly increased the grain yield over K_0 and produced statistically similar grain yield to those of K_{33} and K_{FP} of both T. Aman and wheat crops.**

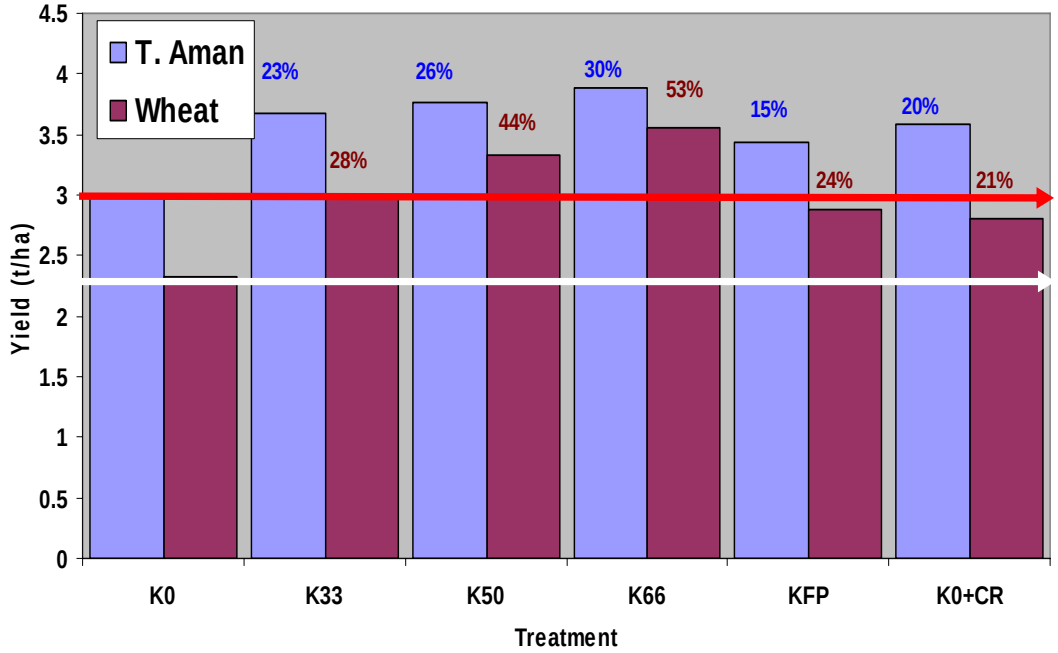


Figure 6. Influence of K fertilizer on the grain yield of rice and wheat (average of 3 years) grown in Wheat - Fallow - T. Aman cropping pattern, HSTU, Dinajpur, 2003-2006

- **Among the treated plots where K fertilizer was applied @ 66 kg K/ha produced the highest grain yield of both rice and wheat.**
- **Crop residues incorporation or chemical fertilizer application as a source of K increased about 15- 30 % grain yield of rice and 21-53 % wheat grain in research trial.**


K_0


K_0+RS


K_{66}


K_{66}+RS

- Soil test based K fertilization (K_{STB}) significantly increased the grain yield of both T. Aman rice and wheat over farmers K-fertilization practice (K_{FP}) and K control in farmers' field demonstrations.

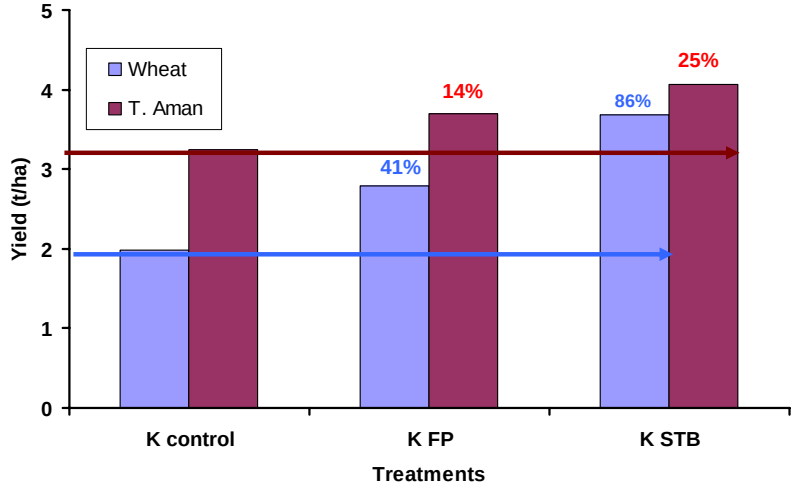


Figure 7. Influence of K fertilizer on the yield of Wheat (average of 13 trials) and T. Aman (average of 14 trials) at farmer's field grown in a Wheat-Fallow-T.Aman cropping pattern,NW of Bangladesh 2003-006

- The contribution of K-fertilizer to grain yield production was found prominent in wheat than that of T. Aman rice.
- The use of K-fertilizer in farmers' field demonstrations produced about 14-25% higher rice yield and 41-86% wheat grain than that of K control.
- The influence of higher K fertilizer to increase grain yield was found more prominent in wheat than that in rice. Soil test based K fertilization (K_{STB}) significantly increased the grain yield of both T. Aman rice and wheat over farmers K-fertilization practice (K_{FP}) and K control in farmers' field demonstrations.


পটাশ সারের মাত্রা :
১। পটাশ সার বন্টন (এম.পি সার =০ কেজি/একর)
২। ফুফকের মাত্রা (এম.পি সার =২৪ কেজি/একর)
৩। মাটি পরীক্ষার ভিত্তিতে (এম.পি সার = ৭০ কেজি/একর)
পটাশ সারের উৎস : মিউরেট অব পটাশ
অন্যান্য সারের মাত্রা (কেজি/একর) :
ইউরিয়া-১১২, টি এস পি-৪০, জিপসাম= ৭৪, দস্তাসার-০.১,
বোরাক্স-৪.০
স্থান : মুক্তাগাছাগন, ময়মনসিংহ।
গবেষক : পি.কে.সাহা, এটি এম শাহাওয়াত হোসেন, এম.এইচ রশিদ ও এম.এ.এমিয়া


পটাশ সার বন্টন
K ০


ফুফকের মাত্রা
K ২৪


মাটি পরীক্ষার ভিত্তিতে
K ৪৭
ভোগনগর

Bangladesh Rice Research Institute

Agronomic Efficiency (kg grain/kg applied K)

Location / Treatment	Gazipur		Dinajpur	
	T.aman (2003-2007)	Boro (2004-2007)	T.aman (2003-2005)	Boro (2004-2006)
K33	18	13	18	20
K50	12	15	24	20
K60	8	10	19	19

- Increase of K doses beyond 33 kg/ha in T.aman and 50 kg in Boro season decreased the K use efficiency in rice.
- The efficiency of applied K fertilizer was found more in sandy loam soil of Dinajpur than that of clay loam soil of Gazipur.

Cost and Return Analysis

Economics of potash fertilizer application to T. Aman rice (mean of five crops), Gazipur.

Experiment location	Treat-ment	Grain yield	Yield increase	Value of extra production	Cost of potash (MOP)	VCR	Net additional income	
		(t/ha)		(Tk./ha)[1]			Tk./ha	USD/ ha
BRRI Experiment-al farm, Gazipur	K_0	3.25	-	-	-	-	-	-
	K_{33}	3.74	0.49	4900	924	5.3	3976	58
	K_{50}	3.82	0.57	5700	1400	4.1	**4300**	62
	K_{66}	3.80	0.55	5500	1848	3.0	3652	53
	$K_{(FP)}$[2]	3.61	0.36	3600	504	**7.1**	3096	45
	$K_{0\pm CB}$[3] ([2]) [2] [2] [3]	3.66	0.41	4100	2250[4]	1.8	1850[4]	27[4]
Fermers' fields	K_0	3.57	-	-	-	-	-	-
	K_{FP}[2]	3.92	0.35	3500	504	6.9	2996	43
	K_{STB}[5]	4.28	0.71	7100	1148	6.2	5952	86

Economics of potash fertilizer application to Boro rice (mean of four crops).

Experiment location	Treat-ment	Grain yield	Yield increase	Value of extra production	Cost of potash	VCR	Net additional income	
		(t/ha)		(Tk./ha)[1]			Tk./ha	USD/ ha
BRRI Experiment-al farm, Gazipur	K_0	4.94	-	-	-	-	-	-
	K_{33}	5.38	0.44	4180	924	4.5	3256	47
	K_{50}	5.70	0.76	7220	1400	**5.2**	**5820**	84
	K_{66}	5.62	0.68	6460	1848	3.5	4612	67
	$K_{(FP)}$ [2]	5.23	0.29	2755	1036	2.7	1719	25
	K_{0+CR} [3]	5.64	0.70	6650	2250[4]	3.0	4400[4]	64[4]
Fermers' fields	K_0	4.41	-	-	-	-	-	-
	K_{FP}[2]	5.14	0.73	6935	1036	6.7	5899	85
	K_{STB}[5]	5.64	1.23	11685	1876	6.2	9809	142

- In clay loam soil at Gazipur, potassium fertilizer applied @ 50 kg/ha in both T. Aman and Boro season appeared to be most economic in terms of additional income.
- While on the basis of value cost ratio (VCR), farmers' fertilization practice in T. Aman and 50 kg K/ha in Boro season was found most suitable.
- The additional income earned due to K-fertilization was much more in dry season rice than that of wet season rice.

Economics of potash fertilizer application to rice (mean of three crops).

Experiment location	Treat-ment	Grain yield	Yield increase	Value of extra production	Cost of potash (MOP)	VCR	Net additional income	
		(t/ha)		(Tk./ha)[1]			Tk./ha	USD/ha
HDSTU Experi-mental farm	K_0	2.98	-	-	-	-	-	-
	K_{33}	3.67	0.69	6900	924	7.5	5976	87
	K_{50}	3.76	0.78	7800	1400	5.6	6400	93
	K_{66}	3.88	0.90	9000	1848	4.9	**7152**	104
	$K_{(FP)}$[2]	3.44	0.46	4600	700	6.6	3900	57
	K_{0+CR}[3]	3.58	0.60	6000	2250[4]	2.7	3750[4]	54[4]
Fermers' fields	K_0	3.25	-	-	-	-	-	-
	K_{FP}[2]	3.70	0.45	4500	672	6.7	3828	55
	K_{STB}[5]	4.06	0.81	8100	1624	5.0	6476	94

Economics of potash fertilizer application to wheat (mean of three crops).

Experiment location	Treat-ment	Grain yield	Yield increase	Value of extra production	Cost of potash	VCR	Net additional income	
		(t/ha)		(Tk./ha)[1]			Tk./ha	USD/ha
HDSTU Experi-mental farm	K_o	2.32	-	-	-	-	-	-
	K_{33}	2.97	0.65	7150	924	7.7	6226	90
	K_{50}	3.33	1.01	11110	1400	7.9	9710	141
	K_{66}	3.55	1.23	13530	1848	7.3	**11682**	169
	$K_{(FP)}$ [2]	2.88	0.56	6160	840	7.3	5320	77
	K_{0+CR} [3]	2.81	0.49	5390	2250[4]	2.4	3140[4]	46[4]
Fermers' fields	K_0	1.98	-	-	-	-	-	-
	K_{FP} [2]	2.79	0.81	8910	868	10.3	8042	117
	K_{STB} [5]	3.68	1.70	18700	2436	7.7	16264	236

- In sandy loam soil of NW region of Bangladesh the maximum additional income in both T. Aman rice and wheat were obtained from the same treatment where K-fertilizer was applied @ 66 kg/ha.
- Applied K from inorganic sources contributed higher benefit than that of crop residue incorporation in both rice and wheat production.
- The additional income earned due to K-fertilization was much higher in wheat than that of rice.

- In the case of farmers' field demonstrations, K fertilization on STB always contributed higher additional benefit than that of farmers' fertilization practice in any season in both heavy and light textured soils.

- The comparable higher VCR was found for wheat crop than that of rice in light textured soils of NW region of Bangladesh.

Conclusion and Recommendation

- Potassium fertilization significantly increased the production of Rice-Rice and Rice-Wheat cropping system.
- Long-term omission of K severely intensified the K problem.
- Initially the decrease of yield of rice and wheat due to K omission was not significant but the yield gap between the balanced fertilized and –K plot widened sharply and significantly with time.

- In light textured soils, crop residue incorporation alone instead of inorganic potash fertilizer gave appreciable yield increase above the control treatment but this increase was far below the effect from inorganic potash fertilizer application.
- Crop residue may be a reasonable additional source of potassium for crop nutrition but the highest productivity is achieved with mineral potash fertilizer use.

- Light textured soil responded notably compared to heavy textured soil to applied K.
- The contribution of applied K fertilizer was found more prominent in dry season rice and wheat compared to wet season rice.

- Application of K fertilizer @ 50 kg/ha at each crop in Rice-Fallow-Rice cropping pattern in clay loam soil and @ 66 kg/ha at each wheat and rice crop in Wheat-Fallow-Rice cropping pattern in sandy loam soil appeared to be economically most viable K fertilizer doses.

- These results indicated the need for increasing the present recommended K fertilizer dose for the MV Rice-Rice and Wheat-Rice crop production system in flood free land of Bangladesh where yearly K replenishment due to alluvial deposition doses not occur.


Thank You