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EFFECTS OF ORGANIC AND INORGANIC SOURCES OF K ON RICE YIELD AND SOIL K BALANCE IN THE RICE-RICE CROPPING SYSTEM

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Abstract

Field experiments were conducted through T. Aman 2003–Boro 2008 at the Bangladesh Rice Research Institute (BRRI), Gazipur Farm with a view to determining the appropriate dose of K fertilizer in soils under double rice cropping system and to find out the alternative source of K for wet land rice cultivation. Four levels of inorganic K (0, 33, 50 & 66 kg K/ha and farmers' practice from MoP) and one recycling of rice straw 4.5 t/ha (dry basis) were tested. Incorporation of rice straw into soil contributed significantly to grain yield in successive growing seasons comparable with inorganic K fertilizer. In clay- loam soil, K at the rate of 50 kg K/ha should be applied to obtain the maximum yield in both T. Aman and Boro rice seasons. Rice straw may be a potential alternative source of K for sustaining soil K fertility and maximizing rice yield. Agronomic use efficiency of K decreased with increasing K levels. A narrower balance of K was observed when rice straw or a higher dose of inorganic K fertilizer was used.

Keywords: K, rice yield, soil K balance, rice straw.

Introduction

Potassium is one of the major nutrients and absorbed in large quantities by crops. Intensive cropping with modern rice varieties is responsible for increasing the K deficiency in soil (Tiwari, 1985). Most of the north-western parts of Bangladesh are deficient in potassium (BARC, 2005). Light texture soil of these areas has low exchangeable K and the farmers use low amount of K fertilizer. As a result, soils which are not deficient in the past, are likely to become deficient in the near future. Potassium deficiency in wetland rice has so far received limited attention. Hidden K deficiency in rice may limit its yield seriously. Regmi *et al*. (2002) reported that depletion of soil K and inadequate K fertilization seem to be the primary reason of limiting and declining yield of the first rice and wheat crop. Shah *et al.* (2008) reported that continuous omission of K in fertilizer schedule for 23 yrs resulted in about 41% reduction of Boro rice yield over 100% NPKSZn fertilization. The general recommended dose of K fertilizer for MV rice in Bangladesh only around 35-40 kg K/ha (BARC, 1997), while an average rice yield (4.0 t/ha) removes at least 70 kg K/ha from the soil. This level of K fertilization may not be adequate for

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sustaining favourable K status of the soil in the long run. Considering these points, the experiment was designed with a view to finding out the appropriate dose of K fertilizer in soils of the investigated area for existing cropping pattern and to find out the alternative source of K for wet land rice cultivation.

Materials and Method

A field experiment was conducted at the BRRI farm, Gazipur (AEZ 28, Madhupur Tract, Medium High Land) during T. Aman 2003 to Boro 2008. The soil of the experimental field was clay-loam in texture and slightly acidic in reaction (pH 6.1). Organic matter, total N, available P, and exchangeable K of the soil were 2.02%, 0.07%, 10 ppm, and 0.17 meq/l00 g soil, respectively. The available S and Zn (EDTA extracted) contents of the soil were 6.1 ppm and 2.8 ppm, respectively. Six doses of potassium were tested. These were: K control (K_0), 33 kg K/ha (K_{33}), 50 kg K/ha (K_{50}), 66 kg K/ha (K_6), farmers' K fertilizer rates based on *25* local farmers (K_{FP}) and recycling of rice straw 4.5 t/ha/crop as oven dry basis (K_{0+CR}). Nutrient contents in rice straw are N-0.5%, P-0.08%, K-1.5%, S-0.09%, and Zn-43 ppm. The soil test based flat doses of N, P, S, and Zn were applied to all the plots. Nitrogen fertilizer was applied in 3 equal splits (1/3 N as basal, 1/3 N at active tillering stage and 1/3 N at 7 days before panicle initiation stage). All other fertilizers (P, K, S & Zn) were applied at the final land preparation. Chopping rice straw of the previous crop @ 4.5 t/ha as oven drys basis were incorporated into soil 10-14 days before transplanting. Thirty days old seedlings of T. Aman rice and 40 days old seedlings of Boro rice were transplanted at 20 cm × 20 cm spacing. In T. Aman season, BRRI dhan31 and in Boro season, BRRI dhan29 were tested. The experiment was laid out in a RCB design with 4 replications. Appropriate cultural and management practices including plant protection measures were taken whenever required. At maturity, the crop was harvested from 5 m^2 area at the centre part of each plot and 16 hills were collected for straw yield. The grain yield was recorded at 14% moisture content and straw yield as oven dry basis. Potassium content of plant samples were determined by standard analytical procedure using di-acid mixture (nitric and perchloric acid at the ratio 5:2) (Yoshida *et al.*, 1972). Data were statistically analyzed using IRRI STAT version 4.1 (IRRI, 1998). Economic analysis was done using standard procedure.

Results and Discussion

Grain and straw yield

Potassium applied either from rice straw or inorganic fertilizer exhibited superior performance in terms of grain yield over K control both in T. Aman and Boro seasons across the years (Table 1). Incorporation of crop residue (RS) into soil at the rate of 4.5 t/ha/crop contributed significantly to get a comparable grain yield of rice in successive growing seasons as produced with inorganic K fertilizer. The yearly average productions of rice grain increased from 8% with farmers' fertilization practice to 17% by applying 50 kg K/ha over K control (Table 1).

Table 1. Influence of K fertilizer on the grain yield (t/ha) of rice in the Boro- Fallow–T. Aman cropping pattern at BRRI farm, Gazipur during 2003-2008.

Treatments	T. Aman (BRRI dhan31)					Boro (BRRI dhan29)					Yearly		
	2003 1st crop	2004 3rd crop	2005 5th crop	2006 7th crop	2007 9th crop	2004 2nd crop	2005 4th crop	2006 6th crop	2007 8th crop[3]	2008 10th crop	Mean yield	Yield increase (%)	AUE[4] (kg grain/kg added K)
K_0	3.09	3.62	3.28	3.39	2.89	4.82	5.11	5.18	4.66	3.61	7.93	-	-
K_{33}	3.25	3.93	3.56	4.46	3.52	5.41	5.6	5.67	4.82	3.90	8.82	11	13.5
K_{50}	3.22	4.16	3.70	4.55	3.47	5.65	6.08	5.77	5.31	4.53	9.29	17	13.6
K_{66}	3.19	4.43	3.64	4.47	3.25	5.33	5.97	5.89	5.30	4.22	9.14	15	9.2
K_{FP}[1]	3.20	3.84	3.54	4.44	3.03	5.12	5.54	5.46	4.80	4.05	8.60	8	12.3
K_{0+CR}[2]	3.10	3.88	3.66	4.51	3.16	5.62	5.82	6.04	5.08	4.11	9.00	14	7.9
LSD (0.05)	NS	0.29	0.22	0.60	0.37	0.19	0.38	0.56	NS	0.53	-	-	-
CV (%)	3.6	4.8	4.1	9.1	7.7	2.3	4.4	6.5	8.6	8.8	-	-	-

[1]FP = Farmers' practice for K based on the average of 25 local farmers (K_{18} in T. Aman & K_{37} in Boro)

[2]CR = Crop residues (4.5 t/ha/crop).

[3]After 1st N top dress the experiment was under water for one day due to heavy rainfall.

[4]AUE = Agronomic Use Efficiency

Notes: Flat dose for T. Aman : N-P-S-Zn @ 97-14-13-0 kg/ha, respectively and Boro N-P-S-Zn @ 145-23-23-0 kg/ha, respectively.

Table 2. Influence of K fertilizer on the straw yield (t/ha) of rice in the Boro - Fallow – T. Aman cropping pattern at BRRI farm, Gazipur during 2003-2008.

Treatment	T. Aman (BRRI dhan31)					Boro (BRRI dhan29)					Yearly	
	2003 1st crop	2004 3rd crop	2005 5th crop	2006 7th crop	2007 9th crop	2004 2nd crop	2005 4th crop	2006 6th crop	2007 8th crop[3]	2008 10th crop	Mean yield	Yield increase (%)
K_0	4.87	3.93	4.22	*6.45*	4.53	6.30	4.97	5.68	4.49	4.19	9.93	-
K_{33}	*5.43*	4.02	5.17	6.77	4.79	*6.58*	*5.43*	5.97	4.43	*4.55*	10.63	7
K_{50}	5.63	4.42	5.2	6.89	5.02	6.82	5.80	5.99	4.60	4.63	11.00	11
K_{66}	5.12	4.57	5.24	6.87	5.12	6.86	5.88	6.06	4.77	4.63	11.02	11
K_{FP}[1]	5.05	4.06	4.81	7.05	5.12	6.57	5.28	6.17	4.60	4,61	10.66	7
K_{0+CR}[2]	4.53	4.43	4.97	6.53	4.74	6.73	5.37	6.46	4.13	5.02	10.58	7
LSD (0.05)	NS	0.28	0.28	NS	NS	0.26	0.24	NS	NS	NS		
CV (%)	12.1	4.3	3.7	9.6	8.2	2.6	2.9	8.1	8.7	8.5		

[1]FP = Farmers' practice for K based on the average of 25 local farmers (K_{18} in T. Aman & K_{37} in Boro)

[2]CR = Crop residues (4.5 t/ha/crop).

[3]After 1st N top dress the experiment was under water for one day due to heavy rainfall.

Notes: Flat dose for T. Aman : N-P-S-Zn @ 97-14-13-0 kg/ha, respectively, and Boro N-P-S-Zn @ 145-23-23-0 kg/ha, respectively.

Rice straw incorporation alone produced 14% increased grain yield over K control. These findings support the results recorded by Saha *et al.* (2009), Ponnamperuma (1984) and Verma and Bhagat (1992). It clearly indicates that rice straw may be a good alternative source of K in rice cultivation. Agronomic use efficiency (AUE) of K (kg grain/ kg added K) varied from 7.9 (K_{0+CR}) to 13.6 (K_{50}). It decreased with the increasing K level regardless of K sources (Table 1). The highest AUE was observed with the treatment K_{50}. The straw yields all over the years are presented in Table 2. The yearly average production of rice straw increased from 7% with farmers' fertilization practice to 11% by applying 50 kg K/ha over K controls (Table 2).

Table 3. Economics of K fertilizer application in T. Aman rice (mean of five crops).

Treatments	Grain yield	Yield increase	Value of extra production	Cost of potash (MoP)	BCR	Net additional income (Tk./ha)
	(Tk/ha)		(Tk/ha)			
K_0	3.25	-	-	-	-	-
K_{33}	3.74	0.49	4900	924	5.3	3976
K_{50}	3.82	0.57	5700	1400	4.1	4300
K_{66}	3.80	0.55	5500	1848	3.0	3652
$K_{(FP)}$ [1]	3.61	0.36	3600	504	7.1	3096
K_{0+CR} [2]	3.66	0.41	4100	2250[3]	1.8	1850[3]

[1] K_{FP} = Farmers' practice for K, based on the average of 25 local farmers that applied 18 and 37 kg K/ha, in T. Aman and Boro rice, respectively.

[2] CR = Crop residues @ 4.5 t/ha both in T. Aman and Boro seasons were applied.

[3] Input cost and additional income with crop residue.

Table 4. Economics of K fertilizer application in Boro rice (mean of five crops).

Treatments	Grain yield	Yield increase	Value of extra production	Cost of potash (MoP)	BCR	Net additional income (Tk./ha)
	(Tk/ha)		(Tk/ha)			
K_0	4.68	-	-	-	-	-
K_{33}	5.08	0.40	3800	924	4.1	2876
K_{50}	5.47	0.79	7505	1400	5.4	6105
K_{66}	5.34	0.66	6270	1848	3.4	4422
$K_{(FP)}$ [1]	4.99	0.31	2945	1036	2.8	1909
K_{0+CR} [2]	5.33	0.65	6175	2250[3]	2.7	3925[3]

[1] K_{FP} = Farmers' practice for K, based on the average of 25 local farmers that applied 18 and 37 kg K/ha, in T. Aman and Boro rice, respectively.

[2] CR = Crop residues @ 4.5 t/ha both in T. Aman and Boro seasons were applied.

[3] Input cost and additional income with crop residue.

Economic analysis

Economic analysis of the potassium fertilization experiment was done with mean data of 5 crops for each season (T. Aman and Boro). Results are presented in Table 3 and 4. In clay loam soil at Gazipur, K fertilizer applied at 50 kg inorganic K/ha in both T. Aman and Boro seasons appeared to be most economic in terms of net additional income. Based on benefit-cost ratio (BCR), farmers' fertilization practice in T. Aman season and 50 kg K/ha in Boro season was found most suitable. It was noted that the additional income from K fertilization was much more in Boro rice than in T. Aman rice.

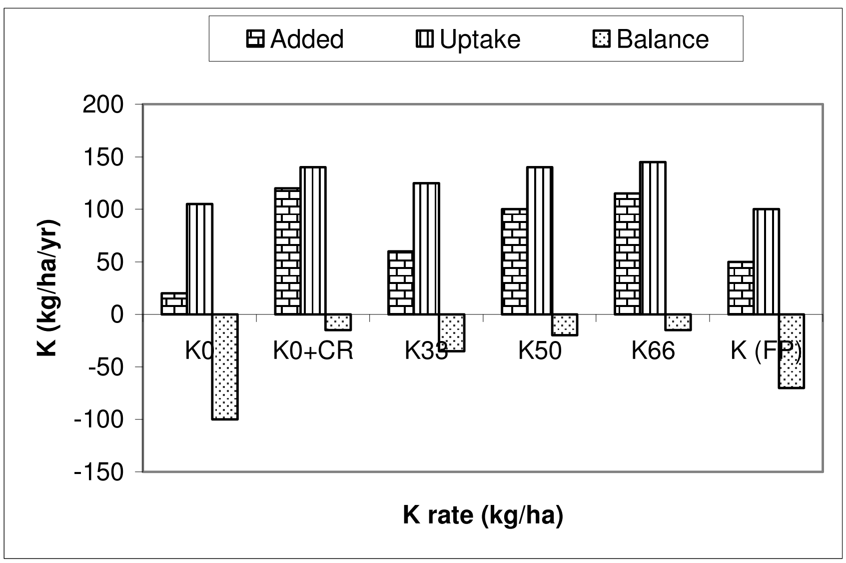

Fig. 1. Apparent K balance as affected by organic and inorganic K fertilizer (average of 5 yrs)

Apparent K balance in soil

Apparent K balance was calculated in a simplified approach. Net K balance was estimated based on *major inputs:* fertilizer and added K through irrigation water and *major outputs:* above ground plant uptake. The apparent balance of K in soil was negative. The magnitude of the negative K balance ranged from-93 (K_0) to-15 (K_{66}/K_{0+CR}) kg/ha/yr. (Fig.1). The magnitude gradually decreased with increasing K levels. However, there was a narrower balance of K, where organic K fertilizer or a higher dose of inorganic K fertilizer was applied (Fig. l).

Conclusion

- In clay loam soil, a rate of 50 kg inorganic K/ha should be applied in both T. Aman and Boro seasons to get a maximum yield of rice.

- Rice straw @ 4.5 t/ha/crop (as oven dry basis) may be a good alternative source of K fertilizer for sustaining soil K fertility and maximizing rice yield in the rice-rice cropping pattern.

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