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EFFECT OF POTASSIUM ON BORO-FALLOW-T. AMAN CROPPING PATTERN IN OLD BRAHMAPUTRA FLOODPLAIN SOIL OF BANGLADESH

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ABSTRACT

Field experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh during 2010-11 to 2011-12 to investigate the effect of different levels of K on Boro-Fallow-T. Aman cropping pattern in Old Brahmaputra Floodplain Soil of Bangladesh. There were four treatments for the first crop (Boro rice): T_1 (Control), T_2 (50% NPKS), T_3 (75%NPKS) and T_4 (100% NPKS). The 100% NPKS rates were recommended on the basis of soil test values. T_4 treated plot of each block was further split into seven sub-plots to represent seven treatments ($T_{4.1}$ to $T_{4.7}$) for the second crop of T. Aman in the sequence. The results reveal that the grain yield of boro rice varied from 2.33 to 6.00 t ha^{-1} of which the highest yield was recorded with the application of 100% NPKS (T_4) and the lowest with T_1 (control). The effect of boro rice straw removal or incorporation was clearly visible on the following crop, T. Aman rice. The highest grain and straw yields of T. Aman were obtained with $T_{4.4}$ treatment, where 75% straw was removed and 25% straw incorporated with soil. The lowest yield was obtained with the control crop without fertilizer or straw residues. The NPKS uptake by T. Aman rice and benefit : cost ratio supported the dominant performances of $T_{4.2}$ (100% NPS + 50% K + 25% boro rice straw removed). The results suggested that it is possible to reduce K mining from soils as well as to reduce the rate of K fertilizer application, substituting by incorporation of rice straw residues in soil system.

Key words: Boro-T. aman sequence, Potassium levels & uptake, Old Brahmaputra Floodplain, Rice residues and Yield

INTRODUCTION

Potassium is often described as the "quality element" for crop production as is necessary for basic physiological formation of sugar and its subsequent movement

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among different parts, synthesis of protein, cell division and growth (Rao et al., 1990). Proper fertilization effectively improves quality and yield of crops, reduce cost, which augmenting farm income. On the contrary, improper fertilization not only reduces crop yield and quality, but also increases cost, reduce and effectiveness of fertilizer use.

The widespread problem of K deficiency as well as K mining due to intensive cropping with HYVs of rice and nutrient imbalance in soil, which can be minimized by judicial application of potassium fertilizer. Higher yield of rice with higher dose of K over the present recommended rate was reported by many workers (Mitra et al., 2001; Sairam et al., 2002; Singh et al., 2006 and Bahmaniar et al., 2007). In the BINA farm soil it is necessary to find out the optimum rate of potassium application for profitable rice production.

Potassium is considered to be the second element in uptake by most of the agricultural crops. On the other hand, there exists a gap between annual K removal by the crops and K addition through external sources. It would be very optimistic part to expect that this deficit of K will be balanced from the native and organic sources. If it is not being stress out the adequate use of potassium in crop production, this gap will widen further with increased target of food production. As evidenced by research findings, a large percentage of sterile or unfilled spikelets are caused by poor pollen viability and this retards carbohydrate translocation due to potassium deficiency (Dobermann and Fairhurst, 2000). Removal of potassium is higher by the modern varieties than the traditional ones. Removal of straw from the field is widespread in Bangladesh, which explains the depletion of soil K reserves at many sites. Straw is the only organic material available in significant quantities to the most rice farmers. Rice straw contains more K compared to other nutrients and therefore it can be used as a source of K supply to crops. Keeping with this in view, the present study designed with different levels of K along with rice straw of previous crop and with other recommended fertilizers to evaluate the incorporation of rice residues for supplying K as measured in terms of its effect on K uptake as well as rice yield.

MATERIALS AND METHODS

Field experiments were conducted at Bangladesh Institute of Nuclear agriculture (BINA) farm, Mymensingh, Bangladesh using the cropping pattern, Boro-Fallow-T. Aman during 2010-11 and 2011-12**.** The soil belongs to Sonatala series under the Agro Ecological Zone of Old Brahmaputra Floodplain of Bangladesh. The soil was silt loam in texture having soil pH 6.5, organic matter content 0.98 and total N 0.09% and available P 13, exchangeable K 0.10 and available S 8 ppm. There were four treatments for the first crop (Boro rice): T_1 - Control, T_2 -50% NPKS, T_3 -75% NPKS and T_4 -100% NPK, respectively and this 100% NPKS rates was recommended on the basis of soil test value. T_4 treated (100%NPKS) plot of each block was further splitted into seven plots to represent seven treatments ($T_{4.1}$ to $T_{4.2}$)

for the second crop of T. Aman rice. The treatments for T. Aman rice were T_1 -Control, T_2 -50% NPKS, T_3 -75%NPKS and $T_{4.1}$ -100% NPKS, $T_{4.2}$ -100% NPS + 50% K + 25% boro rice straw removed, $T_{4.3}$ -100% NPS + 50% K + 50% boro rice straw removed,$T_{4.4}$ -100% NPS + 50% K + 75% boro rice straw removed, $T_{4.5}$ -100% NPS + 75 % K + 25% boro rice straw removed, $T_{4.6}$ -100% NPS + 75% K + 50% boro rice straw removed and $T_{4.7}$ -100% NPS + 75% K + 75% boro rice straw removed, respectively. The experiment was laid out in a randomized complete block design (RCBD) with three replications (block) of each treatment. Each block was divided into ten unit plots for the selected cropping sequence. The unit plot size was 5m x 4m.

Rice cultivars for Boro and subsequent second crop T. Aman were used Binadhan-5 and Binadhan-7, developed in Bangladesh Institute of Nuclear agriculture. Forty and 25-day old seedlings for Boro and T. Aman rice were transplanted in the experimental plots maintaining 3 seedlings in each hill with a spacing of 20 cm x 20 cm. The recommended doses for N, P, K and S for Binadhan-5 were 140, 28, 48 and 22 kg ha^{-1}, respectively, and for Binadhan-7 the doses were 90, 12, 27 and 10 kg ha^{-1}, respectively. Fertilizers were applied as per treatment schedule. The full dose of each of triple superphosphate (TSP), muriate of potash (MoP), gypsum, zinc oxide and 1/3 of urea were applied at the time of final land preparation and rest of urea was applied equally splitted into two, equal splits, one after 15 and second at 35 days after transplanting (DAT). Intercultural operations such as irrigation and weeding were applied as and when required by the crop. Crop was harvested at full maturity. Grain yield was recorded on 14% moisture basis and straw yield on sun-dry basis. Five hills were randomly selected from each plot at maturity to record the yield contributing characters. Grain and straw samples were analyzed for the determination of K content (Knudsen et al., 1982). The K uptake by grain and straw was determined from K content and yield data. All the data were statistically analyzed by F-test and the mean differences were ranked by DMRT at 5% level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

First crop: Boro rice (var. Binadhan -5)

Grain yield

The grain yield of boro rice (var. Binadhan-5) was significantly influenced by different treatments imposed in the experiment in both years (Table 1). In 2010-11 the grain yield of Binadhan-5 varied from 2.33 to 6.00 t ha^{-1}. The treatment T_4 (100% NPKS) produced the highest grain yield of 6.00 t ha^{-1} while the lowest grain yield (2.33 t ha^{-1}) was obtained in the treatment T_1 (Control) which was 89% increase over control. In producing grain yield the treatment may be ranked in the order of $T_4 > T_3 > T_2 > T_1$. In 2011-12 the grain yield of Binadhan-5 varied from 2.25 to 6.24 t ha^{-1}. The treatment T_4 produced the highest grain yield while the lowest value was obtained from the treatment T_1 (control). These results are in agreement with Muangsri et al. (2008) who reported that application of rice straw and rice hull in combination with NPK fertilizer increased rice yield than that with NPK alone. Yield of rice grown on the soil amended with rice straw in combination with NPK fertilizers tended to be higher than that of rice grown on the soil amended with only NPK fertilizers.

Straw yield

Like grain yield, the straw yield of boro rice (var. Binadhan-5) responded significantly due to application of K (Table 1). In 2010-11 the straw yield varied from 2.43-6.75 t ha^{-1}. The highest straw yield (6.75 t ha^{-1}) was recorded in T_3 (75% NPKS) which was statistically similar to that of treatment T_2 (50% NPKS) and treatment T_4 (100% NPKS) and the lowest straw yield (2.43 t ha^{-1}) was observed in the T_1 (Control). In 2011-12 the straw yield of Binadhan-5 varied from 2.50 to 7.50 t ha^{-1} with the highest value in the treatment T_3. Again, the treatment T_1 produced the lowest straw yield. These results are in agreement with Bahmaniar et al. (2007) who found that different levels of potassium had positive effects on yield attributes, grain and straw yields of rice except harvest index and 1000-grain weight.

Potassium uptake by grain and straw of Binadhan-5

The K uptake by grain and straw as well as total K uptake by Binadhan-5 was also significantly influenced by different treatments (Table 2). During 2010-11 the K uptake by grain varied from 4.62 to 16.88 kg ha^{-1} while in straw it ranged from 30.30 to 106.09 kg ha^{-1}. The highest K uptake by grain (16.88 kg ha^{-1}) was recorded in T_3 (75% NPKS), which was statistically different from all other treatments while the lowest value (4.62 kg ha^{-1}) was observed in treatment T_1. On the other hand the highest K uptake by straw (106.09 kg ha^{-1}) as well as total K uptake (120.51 kg ha^{-1}) was found in T_4 (100% NPKS).

During 2011-12 the K uptake by grain varied from 4.28 to 13.73 kg ha^{-1} while by straw it ranged from 32.77 to 127.5 kg ha^{-1}. The highest K uptake by grain (13.77 kg ha^{-1}) was recorded in T_4 (100% NPKS), which was statistically similar to that of treatment T_3 (75%NPKS). On the other hand the highest K uptake by straw (127.5 kg ha^{-1}) as well as total K uptake (139.9 kg ha^{-1}) was found in T_3 (75%NPKS) which was statistically similar to that of treatment T_4 (100% NPKS). The lowest values were found in T_1 (control). These results are well corroborated with Mitra et al. (2001) who reported that the uptake of K was increased significantly with the increase in K levels for rice.

Second Crop: T. Aman (Var. Binadhan-7)

Grain yield

The grain yield of Binadhan-7 was also influenced significantly due to different treatments (Table 2). In 2010-11 the grain yield varied from 2.27 to 4.60 t ha^{-1}. The highest grain yield (4.60 t ha^{-1}) was obtained in $T_{4.4}$ (100% NPS + 50% K + 75% boro rice straw removed) while the lowest grain yield (2.27 t ha^{-1}) was found in T_1 (Control). The grain yield due to different treatments ranked in order of $T_{4.4} > T_{4.6} > T_{4.1} > T_{4.3} > T_{4.5} > T_{4.7} > T_3 > T_{4.2} > T_2 > T_1$. It was also shown that the grain yield of Binadhan-7 in 2011-12 ranged from 2.33 to 4.87 t ha^{-1}. The treatment $T_{4.7}$ (100% NPS + 75% K + 75% boro rice straw removed) gave the highest grain yield (4.87 t ha^{-1}) while the lowest value (2.33 t ha^{-1}) was obtained from the treatment T_1. This might be due to the release of additional K from rice straw left in the land. These results somehow support the findings of Bachkaiya et al. (2007) who reported that the grain yield of rice was influenced markedly with differently levels of K and 200 kg K ha^{-1} gave the highest grain yield.

Straw yield

The straw yield of T. Aman rice (var. Binadhan - 7) was significantly influenced by the different treatments (Table 5). The straw yield ranged from 3.87 to 7.60 t ha^{-1} in 2010-11 while in 2011-12 it varied from 3.53 to 6.93 t ha^{-1}. In 2010-11 the highest straw yield was observed in $T_{4.2}$ (100% NPS + 50% K + 25% boro rice straw removed) while in 2011-12 the highest straw yield was observed in $T_{4.7}$ (100% NPS + 75% K + 75% boro rice straw removed). In both years the treatment T_1 (Control) produced the lowest straw yield. This is supposed to be the addition of K from rice straw left in the land that exerted yield increase. Bahmaniar et al. (2007) also reported that K along with rice straw incorporation increased grain and straw yields of rice.

Potassium uptake by grain and straw of Binadhan -7

The K uptake by grain and straw as well as total K uptake of Binadhan-7 was also significantly influenced by the different treatments (Table 4). During 2010-11 the K uptake by grain varied from 4.52 to 16.52 kg ha^{-1} while in straw it ranged from 34.73 to 77.09 kg ha^{-1}. The highest k uptake by grain and straw was recorded in $T_{4.6}$ (100% NPS + 75% K + 50% boro rice straw removed), which was statistically different from all other treatments. The lowest K uptake was found in T_1 (Control). On the other hand, the total K uptake ranged from 39.25 to 93.61 kg ha-^{1} with the highest value in treatment $T_{4.6}$.

Table 4 also shows that the k uptake by grain, straw as well as total K uptake by Binadhan–7 during 2011-12 responded significantly due to different treatments. The highest K uptake by grain (12.11 kg ha^{-1}) was found in $T_{4.6}$ (100% NPS + 75% K + 50% boro rice straw removed), while the lowest value (3.50 kg ha^{-1}) was observed in absolute control treatment. The total K uptake varied from 57.50-131.1 kg ha^{-1}. The highest total K uptake (131.1 kg ha^{-1}) was found in $T_{4.3}$ (100% NPS + 50% K + 50% boro rice straw removed). The lowest total K uptake (57.50 kg ha^{-1}) was observed in T_1. These results are well corroborated with Muangsri et al. (2008) who reported that the K uptake of rice without fertilizer was the lowest and application of rice hull in combination with NPK fertilizer increased K absorption and uptake than with NPK alone.

ECONOMIC ANALYSIS

For economic analysis, the variable costs were considered and the fixed costs were ignored. Variable costs included variable money costs and variable opportunity costs. Variable money cost was the purchasing price of fertilizers and variable opportunity cost included the amount of money paid for carrying and broadcasting of fertilizers. Gross return was calculated as the total value of grain and straw. Table 5 shows the cost and benefit of different treatments used in the experiment. Among the treatments, $T_{4.6}$ gave the highest benefit-cost ratio (4.38). The second highest benefit-cost ratio was found in treatment $T_{4.4}$ (4.32). The minimum benefit-cost ratio was observed in treatment $T_{4.1}$ (3.49). Thus the use of 100% NPS + 75% K + 50% Boro rice straw was found to be more effective and beneficial for T. Aman rice production.

CONCLUSION

Rice straw in combination with K fertilizer could be a good option for supplying K for rice production in Bangladesh. The use of 100 kg N ha^{-1}, 27 kg of P ha^{-1}, 48 kg of K ha^{-1}, 22kg of S ha^{-1} for Boro rice and 90 kg N ha^{-1}, 27 kg of P ha^{-1}, 36 kg of K ha^{-1}, 10 kg of S ha^{-1} and 50% rice straw removed from previous crop for T. Aman can be the best treatment combination for the Boro-Fallow-T. Aman cropping pattern. However, similar study needs to be done in other areas of Bangladesh for location specific recommendation.

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Table 1: Grain and straw yield of Boro rice (var. Binadhan-5) as influenced by different levels of K

Treatment	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2010-11	**2011-12**	**2010-11**	**2011-12**
T_1 (Control)	2.33c	2.25c	2.43b	2.50c
T_2 (50% NPKS)	4.40b	4.13b	6.38a	6.25b
T_3 (75% NPKS)	4.87b	4.95ab	6.75a	7.50a
T_4 (100% NPKS)	6.00a	6.24a	6.53a	7.17ab
CV (%)	9.29	10.67	9.85	9.16
SE (±)	0.41	0.27	0.54	0.308

In a column, figure (s) followed by the same letter (s) do not differ significantly at 5% level by DMRT, SE (±) - Standard error of means

Table 2: Effect of K on the potassium uptake by grain and straw of Boro rice

Treatment	K uptake (kg ha^{-1})					
	2010-11			**2011-12**		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**
T_1 (Control)	4.62c	30.30b	34.92b	4.28c	32.77c	37.03c
T_2 (50% NPKS)	12.73b	72.11c	84.84c	8.26b	102.5b	110.7b
T_3 (75% NPKS)	16.88a	82.47b	99.35b	12.38a	127.5a	139.9a
T_4 (100% NPKS)	14.42b	106.09a	120.51a	13.73a	125.1a	138.9a
CV (%)	2.67	4.71	7.71	8.71	4.50	4.29
SE (±)	1.42	8.36	9.59	0.482	2.52	2.64

In a column, figure (s) followed by the same letter (s) do not differ significantly at 5% level by DMRT, SE (±) - Standard error of means

Table 3: Grain and straw yield of T. Aman (var. Binadhan-7) as influenced by different levels of K

Treatment	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2010-11	2011-12	2010-11	2011-12
T_1	2.27d	2.33c	3.87f	3.53c
T_2	3.80c	3.50b	5.90de	5.25a
T_3	4.33ab	4.10ab	5.70e	6.48a
$T_{4.1}$	4.40ab	4.37ab	6.30cde	6.73a
$T_{4.2}$	4.10bc	4.27ab	7.60a	6.51a
$T_{4.3}$	4.37ab	4.33ab	7.20ab	7.30a
$T_{4.4}$	4.60a	4.53ab	6.70bcd	6.75a
$T_{4.5}$	4.33ab	4.20ab	6.70bcd	6.42a
$T_{4.6}$	4.47ab	4.60ab	6.60bcd	6.28a
$T_{4.7}$	4.33ab	4.87a	7.10abc	6.93a
CV (%)	6.31	9.71	6.92	8.48
SE (±)	0.13	0.325	0.20	0.304

In a column, figure (s) followed by the same letter (s) do not differ significantly at 5% level by DMRT, SE (±) - Standard error of means

Table 4: Effect of K on the potassium uptake by grain and straw of T. Aman rice

Treatment	K uptake (kg ha^{-1})					
	2010-11			2011-12		
	Grain	Straw	Total	Grain	Straw	Total
T_1	4.52g	34.73d	39.25d	3.50f	54.0e	57.50f
T_2	10.54ef	62.08c	72.62c	7.00e	85.54d	92.54e
T_3	11.38de	70.31abc	81.69bc	8.01cde	105.0c	113.2d
$T_{4.1}$	9.18f	71.67ab	80.85bc	7.42de	109.6bc	116.2cd
$T_{4.2}$	14.59b	67.63bc	82.22b	9.46bc	107.5bc	115.6cd
$T_{4.3}$	12.62cd	73.90ab	86.52ab	9.01cd	123.3a	131.1a
$T_{4.4}$	13.54bc	75.92ab	89.46ab	11.15ab	111.4b	120.5bc
$T_{4.5}$	11.33de	72.39ab	83.72b	7.95cde	107.2bc	114.3d
$T_{4.6}$	16.52a	77.09a	93.61a	12.11a	108.8bc	120.3bc
$T_{4.7}$	9.60f	74.04ab	83.64b	7.84cde	118.6a	126.4b
CV (%)	5.28	3.40	5.29	8.24	2.82	2.80
SE (±)	0.60	2.31	2.78	0.58	1.67	1.78

In a column, figure (s) followed by the same letter (s) do not differ significantly at 5% level by DMRT, SE (±) - Standard error of means

Table 5: Production economic analysis of Boro-Fallow-T. Aman cropping pattern

Treatment	Economic Yield (kg ha^{-1})		Gross return (Tk)	Added cost over control (Tk)	Added benefit over control (Tk)	Gross margin over control (Tk)	MBCR
	Grain	Straw					
T_1	4590	6165	75015	-	-	-	-
T_2	6915	8862	112587	8887	37572	28685	4.23
T_3	8025	12213	132588	13331	57573	44242	4.30
$T_{4.1}$	8270	13030	137080	17775	62065	44290	3.49
$T_{4.2}$	8370	14100	139650	17025	64635	47610	3.80
$T_{4.3}$	8700	14500	145000	17025	69985	52960	4.11
$T_{4.4}$	9013	13450	148645	17025	73630	56605	4.32
$T_{4.5}$	8530	13120	141070	17400	66055	48655	3.80
$T_{4.6}$	9200	14030	152030	17600	77015	59415	4.38
$T_{4.7}$	9070	12880	148930	17400	73915	56515	4.25

Grain - 15 Tk. kg^{-1}, Straw - 1.00 Tk. kg^{-1}, N -12 Tk. kg^{-1}, P- 22 Tk. kg^{-1}, K - 25 Tk. kg^{-1}, S - 10 Tk. kg^{-1}, MBCR - Marginal benefit cost ratio