Site-Specific Potassium Management for Rice Grown in Selected Alluvial Soils of West Bengal

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Site-specific K management (SSKM) was evaluated in three selected rice growing areas of West Bengal in four farmers' fields at each site. At all the sites, a statistically significant increase (p=0.05) in grain yield under SSKM treatments ($SSKM_1$ and $SSKM_2$) was observed over state recommended doses (SR_1 and SR_2) and farmers' practice (FFP). The relative agronomic efficiency (RAE) and agronomic use efficiency of K (AEK) was found to be highest for the treatment $SSKM_2$ and SR_1, respectively. But in the case of internal use efficiency of K, no such differences were observed among the treatments.

A number of experiments conducted by scientists at the Agricultural Universities and the State Government Research Organizations in West Bengal, India, showed that there is major depletion of different forms of soil P and K under cropping with inadequate or no applications of these fertiliser nutrients. Based on recent statistics (Department of Agriculture, Government of West Bengal, 2005) of the approximate addition and uptake of different nutrients in some important cropping sequences of West Bengal, the balance of K ranged from -123 kg/ha in rice-rice cropping sequence to -310 kg/ha in rice-potato-sesame cropping sequence. This highlights the mining of the native soil K reserve even under the current state recommended doses of K addition. While formulating the latter K balance, only the readily available portion of soil K is taken into account, without giving due consideration to the native K supplying power of the soils as well as the dynamics of different forms and/or fractions of soil K. As a result, the present recommendations for K generally prove to be sub-optimal in West Bengal and this calls for site-specific recommendations of K on the basis of soil test results. Future strategies for nutrient management in intensive cropping systems ought to be more site-specific and dynamic to manage spatially and temporally variable resources based on a quantitative understanding of the congruence between nutrient supply and crop demand.

Experiments were conducted in selected rice growing areas of alluvial tracts of West Bengal, India, namely Nonaghata Uttarpara (Site I), Telegacha (Site II), and Moratripur (Site III) of Nadia district, with a cropping sequence of jute-rice-rice. Rice (var. I.E.T.-4786) was the second crop of the above mentioned cropping sequence. At each site, a number of soil samples were collected from different farmers' fields to examine the spatial variability in respect to available, as well as non-exchangeable, K pool in the soils. Considering these data, four farmers from each site were selected.

Descriptive statistics of the measured soil properties from the selected soil samples are given in **Table 1**. With the exception of pH, the measured soil properties varied to a great extent as revealed by the coefficient of variation. Amounts of different forms of K in the selected sites are given in **Table 2**. The available pool (water soluble and exchangeable form) varied to a greater extent than did the reserve pool (nonexchangeable and mineral forms) of K (**Table 2**). In general, total K content was higher at Site II, followed by Site III and I. Based on such variability of different forms of K, six treatments designed for the present study were the following: (1) state recommended dose of NPK – 100 % (SR_1); (2) 150 %

Table 1. Descriptive statistics of the measured soil properties at the three experimental sites evaluating soil K in West Bengal.

Property	Minimum	Maximum	Mean	Standard deviation	CV, %
pH	6.43	7.30	6.84	0.31	4.56
EC (dS m)	0.10	0.27	0.15	0.05	34.3
CEC [cmol (p+)/kg]	8.90	16.5	12.3	2.40	19.4
Organic carbon, g/kg	4.00	7.00	5.20	1.19	23.1
Sand, %	14.7	18.5	17.3	1.21	7.00
Silt, %	49.6	56.4	53.2	2.21	4.16
Clay, %	20.3	34.5	28.7	3.74	13.1
Exchangeable (Ca^{+2} + Mg^{+2}) [cmol (p^+)/kg]	7.32	14.3	10.8	2.39	22.1
Available N, kg/ha	16.7	53.7	24.3	103	42.3
Available P_2O_5, kg/ha	21.4	74.2	40.9	17.3	42.3
Available K_2O, kg/ha	73.0	156	116	28.2	24.3
Available sulphur, kg/ha	25.8	640.	106	171	162
Available boron, kg/ha	0.11	2.24	0.62	0.56	90.9
Available copper, kg/ha	6.05	32.5	11.1	7.84	70.9
Available iron, kg/ha	38.1	283	140	79.3	56.6
Available manganese, kg/ha	3.81	84.6	31.1	25.6	82.3
Available zinc, kg/ha	0.56	5.26	2.06	1.44	69.6

Abbreviations and notes for this article: K = potassium; P = phosphorus; N = nitrogen; C.D. = Critical Difference.

Table 2. Distribution of different forms of K in initial soil samples from the 0 to 20 cm depth.

	Forms of K, cmol (p^+)/kg				
Soils	WSK[1]	EXK[2]	NEK[3]	Mineral K[4]	Total K
Site I					
F_1	0.03	0.09	5.07	38.4	43.6
F_2	0.03	0.05	3.83	33.5	37.4
F_3	0.04	0.06	5.84	43.8	49.7
F_4	0.05	0.12	4.36	37.8	42.2
Site II					
F_5	0.03	0.14	5.32	44.6	50.0
F_6	0.04	0.09	6.17	47.3	53.6
F_7	0.02	0.06	4.53	42.7	47.4
F_8	0.03	0.08	3.83	39.4	43.4
Site III					
F_9	0.04	0.12	5.17	43.5	48.8
F_{10}	0.03	0.09	4.25	36.8	41.2
F_{11}	0.04	0.08	6.07	47.6	53.8
F_{12}	0.03	0.11	3.96	37.4	41.5
Min	0.02	0.05	3.83	33.50	37.40
Max	0.05	0.14	6.17	47.60	53.80
Min	0.03	0.091	4.89	41.00	45.50
S.D.	0.001	0.027	0.86	4.47	5.24
CV%	23.13	30.03	17.62	10.89	11.39

[1]WSK, [2]EXK, [3]NEK are the water soluble, exchangeable, and nonexchangeable forms of K, respectively.

[4] Estimated by subtracting the sum of water soluble, exchangeable, and nonexchangeable K from total K contents.

F_1 – F_{12} denote the 12 farmers' fields of the three sites.

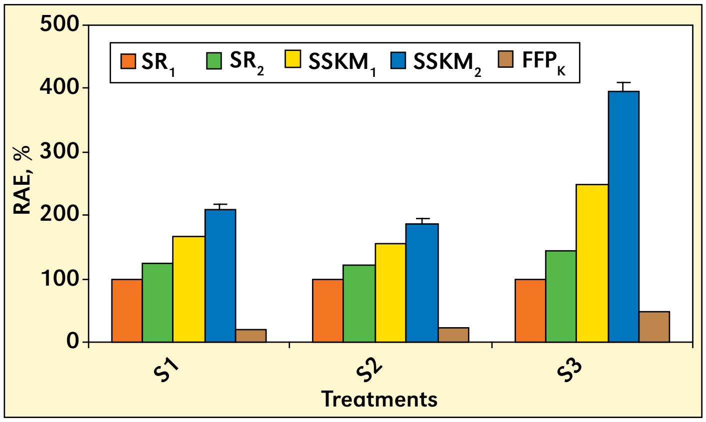

Figure 1. Relative Agronomic Efficiency (RAE) of rice as influenced by different fertilisation.

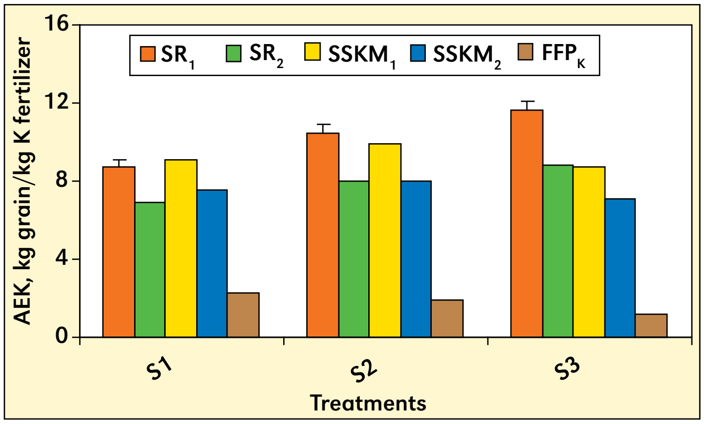

Figure 2. Agronomic Use Efficiency of K (AEK) of rice as influenced by different fertilisation.

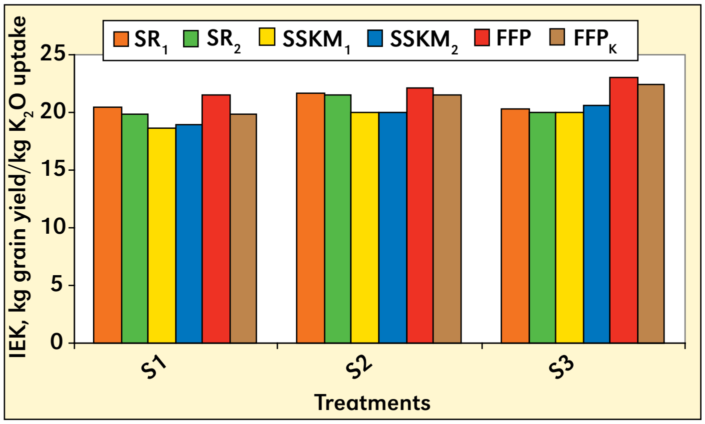

Figure 3. Internal use efficiency of K (IEK) of rice as influenced by different fertilisation.

(SR_2); (3) site-specific K management doses – 100% ($SSKM_1$); (4) 150% of SSKM ($SSKM_2$); (5) farmers' fertiliser practice (FFP); and (6) farmers' fertiliser practice with K adjustment to state recommended doses (FFP_K). In SSKM treatments, N and P were applied based on the soil testing and K was applied by computing a factor with respect to available and nonexchangeable pools of K to maintain the balance between K mining and a productivity target. The full quantities of P and K were applied at transplanting, while N was applied in splits between transplanting and 45 days after transplanting. Recommended cultural and plant protection measures were used throughout the experiment.

Mean grain yield of rice at each site under early treatment is given in **Table 3**. At all the sites, a statistically significant increase (p=0.05) in grain yield under site-specific K management treatment ($SSKM_1$) was observed over the state recommended doses (SR_1) (**Table 3**). Interestingly, there were also significant yield differences between SR_2 and $SSKM_1$ treatment, which implies that even a 50% increment in the state recommendation was not sufficient to reach the level of yield achieved by the $SSKM_1$ treatment (**Table 3**). While the highest average grain yield of the three sites (3.47 t/ha) was observed in the case of $SSKM_2$, the lowest was recorded under FFPs (2.26 t/ha). There was also statistically significant response observed when farmers' practice doses were adjusted upwards with respect to K to FFP_K (the average grain yield being 2.43 t/ha), which indicates that farmer practice doses for K were

Table 3. Response of site-specific balanced fertilisation on rice crop at the experimental sites in West Bengal.

Site	Treatment	Mean grain yield, t/ha		Mean K uptake, kg K_2O/ha		Mean residual crop available K, kg K_2O/ha in soil
		Grain	Straw	Grain	Straw	
Site I						
	SR_1	3.09	3.79	15.0	136	98.5
	SR_2	3.28	4.04	16.7	149	116
	$SSKM_1$	3.65	4.57	20.8	175	143
	$SSKM_2$	4.03	5.02	23.6	189	160
	FFP	2.23	3.24	12.4	91.5	94.0
	FFPK	2.39	3.65	13.4	107	96.8
	S.E.m (±)	0.030	0.129	0.581	3.05	3.78
	C.D. (p=0.05)	0.087	0.375	1.68	8.83	10.95
Site II						
	SR_1	3.34	4.11	16.3	138	109
	SR_2	3.54	4.39	17.5	147	129
	$SSKM_1$	3.86	4.86	21.3	173	142
	$SSKM_2$	4.16	5.08	22.6	186	159
	FFP	2.38	3.38	13.3	94	100
	FFPK	2.59	3.55	14.3	106	106
	S.E.m (±)	0.041	0.038	0.460	1.82	5.05
	C.D. (p=0.05)	0.122	0.111	1.33	5.29	14.64
Site III						
	SR_1	2.51	3.42	12.7	111	124
	SR_2	2.63	3.57	13.5	118	140
	$SSKM_1$	2.89	3.73	15.1	129	164
	$SSKM_2$	3.23	3.93	17.8	139	180
	FFP	2.18	3.28	11.1	83.3	117
	FFPK	2.31	3.36	11.8	91.5	122
	S.E.m (±)	0.072	0.073	0.472	2.41	1.48
	C.D. (p=0.05)	0.209	0.210	1.37	6.98	4.29

sub-optimal (**Table 3**). The highest grain yield of 4.16 t/ha was recorded at Site II in treatment $SSKM_2$, whereas FFP produced the lowest grain yield of 2.18 t/ha at Site-III (**Table 3**). Straw yields showed a similar response to treatment with a little less prominent change compared to grain yield.

The K uptake by rice straw and grain was also significantly influenced by fertiliser treatment (**Table 3**). The K uptake by rice straw was 3 to 8 times higher than that by rice grain at each site for the sown variety (IET-4786). This was much more than one would expect from the relative yields of such rice straw and grain, due obviously to preferential utilization of K in the build-up of mechanical tissues of the crop.

Potassium uptake was significantly greater in $SSKM_1$ and $SSKM_2$ than in SSR_1 and SR_2. The lowest K uptake was recorded under the FFP treatment, but a significant increase in K uptake was found under the FFP_K treatment. At site I and II, K uptake was at par, whereas at Site III, the yield suffered due to flash flooding which caused a reduction of yield, and thereby K uptake.

Data presented in **Table 3** revealed that the build-up of the plant-available soil K pool at harvest of rice was significantly influenced by different levels of K application. The plant-available residual soil K was found to be higher at Site III than that at the other sites (**Table 3**). In general, the residual K status was higher in site-specific K management doses as compared to the farmers' practice as well as the state recommended doses. The K-adjusted treatment FFP_K also showed appreciable build-up of soil K (even in some cases at par with the state recommendation) as compared to FFP treatment.

The relative agronomic efficiency (RAE) values were calculated using the SR_1 treatments as the standard and the FFP as the control. Data for both crops at the three experimental sites is presented in **Figure 1**. The RAE values under $SSKM_2$ were highest (much in excess of 100%) at each site, while FFP_K exhibited the lowest value. The RAE for SR_2 was 30% higher than that in SR_1, while RAE under $SSKM_2$ was 74% higher than $SSKM_1$.

The agronomic use efficiency for K fertilizer (AEK) was found to be higher on average in treatment SR_1 and $SSKM_1$ (the averages being 10.3 and 9.24 kg grain/kg K fertiliser, respectively). These data suggest that (except for the FFP_K treatment) with the increase of K rates, the imbalance of N and P against K may restrict agronomic use efficiency of K at the higher doses of application, namely SR_2 and $SSKM_2$. Among the three sites, Site III showed comparatively higher AE_K values for the given rice crop (**Figure 2**).

Despite slightly higher internal use efficiency (IE_K)

IPNI Crop Nutrient Deficiency Photo Contest—2008

While the classic symptoms of crop nutrient deficiencies are not as common in fields as they were in the past, they do still occur. To encourage field observation and increase understanding of crop nutrient deficiencies and other conditions, the International Plant Nutrition Institute (IPNI) is sponsoring a photo contest during 2008.

"We hope this competition will appeal to practitioners working in actual production fields," said IPNI President Dr. Terry Roberts. "Researchers working under controlled plot conditions are also welcome to submit entries. We encourage crop advisers, and others to photograph and document deficiencies in crops."

Some specific supporting information is required for all entries, including:

- The entrant's name, affiliation, and contact information.
- The crop and growth stage, location, and date of the photo.
- Supporting and verification information related to plant tissue analysis, soil test, management factors, and additional details that may be related to the deficiency.

There are four categories in the competition: Nitrogen (N), Phosphorus (P), Potassium (K), and Other. Entries are limited to one per category (one individual could have an entry in each of four categories). Cash prize awards are offered in each of the four categories as follows:

- First place = US$150
- Second place = US$75
- Third place = US$50

Photos and supporting information can be submitted until the end of calendar year 2008 (December 31, 2008) and winners will be announced in January of 2009. Winners will be notified and results will be posted at the website.

Entries are encouraged from all regions of the world. However, entries can only be submitted electronically as high resolution digital files to the organization's website, at >**www.ipni.net/photocontest**<.

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Shown at right are some photos as examples of deficiency symptoms. BC-INDIA

Nitrogen deficiency in corn.

Phosphorus deficiency in cotton.

Potassium deficiency in soybeans.

Sulphur deficiency in canola.

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for applied K (22.3 kg grain yield/kg K_2O uptake) associated with farmers' practice, there were no differences among treatments (**Figure 3**). This suggests that the sown variety of rice used K fertilizer with equal efficiency regardless of treatment. BC-INDIA

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Reference

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