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CRITICAL LEVEL OF POTASSIUM OF SOME REPRESENTATIVE BANGLADESH SOILS AS DETERMINED BY USING TWO DIFFERENT MODELS

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Abstract

Soil-potassium of a few widely varying representative Bangladesh soils was assessed by four different extractants viz., neutral 1N NH_4OAc (K_{AA}), Agro Services International (ASI) (K_{AS}), acidified 1M NaCl (K_{NaCl}) and boiling 1N HNO_3 (K_{NA}) for wetland rice and upland wheat. The critical levels of potassium in these soils were determined by using the Cate-Nelsen graphical method and the statistical method of Waugh *et al.* The critical values obtained by these two methods were 0.072 (K_{AA}), 0.108 (K_{AS}), 0.09 (K_{NaCl}) and 10.66 (K_{NA}) meq% for rice and 0.102 (K_{AA}), 0.126 (K_{AS}), 0.089 (K_{NaCl}) and 0.54 (K_{NA}) meq% for wheat. The values correlated well between the Cate-Nelson graphical method and the statistical procedure of Waugh et al. On the basis of these values, soils expected to be responsive of potassium fertilization were classified.

Introduction

A successful potassium fertilization programme depends, among many factors, on the status and the critical level of the element in soil. There was a general impression among the crop and soil scientists of the country that Bangladesh soils were well supplied with potassium and did not need any supplemental potassium (1). During recent years, however, well spread responses to added K-fertilizers have been reported. The efficiency of K-fertilizer use in the country is thought to be low compared to many other countries (2). Moreover, contradictory observations have been made on the critical level of soil-K. This is due particularly to the variation of extracting reagents as well as the methods employed to determine the critical level. It is thus, pertinent not only to determine the critical deficiency levels using different extractants but also to do so by using different models for various crops.

Literatures relating to K-fertilizer recommendation based on soil-K critical values contains somewhat contradictory reports (3-5). Their values vary between 0.18 to 0.26 meq% for rice assessed with neutral 1N NH_4OAc. A value of 0.2 meq% is usually considered, but IRRI (6) considers that 0.2 meq K/100 g soil may be too high a value for K-deficiency in countries like Bangladesh. Moreover,

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availability of potassium to crops under wetland codition would be different from that under upland condition and therefore, critical level of potassium established for upland crops may not hold good for wetland crops. In fact, many K-rate trials showed no significant response of wetland rice to added potassium even when the soil K-test values were much below 0.2 meq% (7). Saleque *et al.* (8) reported a critical soil potassium of 0.075 meq% by neutral 1N NH_4OAc for wetland rice. In a recent study, Bhuiyan *et al.* (7) reported that the critical level of soil-K for wetland rice is to be considered 0.1 meq% instead of 0.2 meq%. Keeping these facts in view, the present research was undertaken to verify the contentions of Bhuiyan *et al.* (7) and to re-establish the critical level of soil-K of eleven representative soil series of the country for wetland rice and upland wheat by using four different commonly used extractants and employing two different models.

Materials and Methods

Eleven representative soil series varying in their parent materials and other properties and supposed to have different potassium contents were included in the present study. The soil series were Chandina, Chandra, Ghatail, Kalma, Khadimnagar, Mirsarai, Noadda, Pirgacha, Ranisankail, Sonatala and Tejgaon. The soil samples were collected at a depth of 0-15 cm from surface at different sites of Bangladesh. Some of the basic properties and general features of the eleven soils are presented in Table 1. The soil samples were analysed after usual processing for extractable-K by using neutral 1N NH_4OAc (9), Agro Services International-ASI (10) extractant, 1M NaCl acidified to pH 3.0 (11) and boiling 1N

Table 1. Some properties of the soil series under study.

Soil series	pH	Texture	C. E. C. meq%	O.C. (%)	Total N(%)	C : N Ratio	Avail N (ppm)	Avail P (ppm)
Chandina	4.8	SiL	8.4	0.78	0.08	8.8	130	11.0
Chandra	4.5	SCL	8.4	0.80	0.07	8.8	80	12.0
Ghatail	6.1	C	21.5	0.85	0.17	5.6	280	3.0
Kalma	5.0	SiL	15.3	0.67	0.13	8.7	130	4.2
Khadimnagar	5.5	L	8.8	1.13	0.08	8.8	80	1.8
Mirsarai	4.8	L	13.2	0.41	0.10	4.1	280	8.0
Noadda	4.5	SCL	12.8	1.00	0.12	8.3	80	10.0
Pirgacha	4.5	SL	8.9	0.58	0.07	8.4	60	10.7
Ranisankail	4.8	SL	8.2	0.65	0.08	7.2	110	22.0
Sonatala	4.8	SiL	7.8	0.81	0.09	9.0	180	8.1
Tajgaon	5.5	CL	12.3	0.87	0.07	8.8	140	8.0

HNO_3 (9). The corresponding K-values are designated as K_{AA}, K_{AS}, K_{NaCl} and K_{NA} respectively.

Pots of 1 l size were used in this study. The basal applications of N and P_2O_5 were selected according to the Fertilizer Recommendation Guide (12) on the basis of soil analysis values for N and P. The K-application doses were at the rates of 0, 20, 40, 60, 80, 100, 120 and 140 kg/ha. The sources of N, P and K were urea, TSP and MP respectively. BR22 variety of rice and Kanchan variety of wheat were used as test crops. The rice seedlings were procured from the Bangladesh Rice Research Institute (BRRI) while the seeds of wheat were procured from the Bangladesh Agricultural Research Institute (BARI). There were four replicates in each treatment. The treatments were arranged randomly. The position of the pots were rearranged every alternate day to facilitate equal exposure to sunlight. At the maxium tillering stage the plants were cut at ground level, cleaned and dried at 80 ± 5°C for 48 h to get the d. m. yield.

The critical levels of potassium for the four extractants were determined separately using the models of Cate-Nelson (13) and Waugh *et al.* (14). According to Cate-Nelson (13) graphical procedure, relative yield ($Y_1/Y_2 \times 100$, where Y_1 is the yield at no-K, Y_2 is the maximum yield obtained in K-fertilized pot) was calculated for each soil series. A scatter diagram of relative yield versus soil-K test values was plotted on an arithmetic paper. A pair of intersecting perpendicular lines were drawn on the plotted paper in such a way that the line parallel to the X-axis intersected the Y-axis at a relative yield between 75% and 80% (in our case it was 77%) and the line parallel to the Y-axis was drawn in such a way that the number of points in the negative quadrants were the minimum. The intersecting point of this line on the X-axis was considered the "critical" soil-K level.

In the Waugh *et al.* (14) statistical model, relative yield (Y) was calculated as in Cate-Nelson procedure and the values were ordered along with the corresponding soil-K test values (X). The (X, Y) pairs were maintained in this order throughout the analysis. The R^2 values of two groups were calculated by using successive tentative critical levels of two groups. The maximum R^2 value obtained for the group was considered the range of critical value. The mean of the two classes was the predicted critical value.

Results and Discussion

Soil-K test values. The soil-K test values ranged from 0.06 to 0.27 meq% soil for K_{AA}, 0.1 to 0.29 meq% soil for K_{AS}, 0.06 to 0.19 meq% soil for K_{NaCl} and 0.5 to 2.25 meq% soil for K_{NA} (Table 2a, b).

Table 2. Extrctable soil-K, crop yield and per cent relative yield (RY).

(a) for rice (BR22) :

Soil series	Extractable K (meq%)				Rice yield (g d. m./kg)		RY (%)
	NH_4OAc	ASI	NaCl	HNO_3	No K	With K*	
Chandina	0.08	0.12	0.08	0.63	5.85	7.37	78
Chandra	0.06	0.10	0.06	0.50	4.83	7.85	62
Ghatail	0.13	0.14	0.10	1.98	6.48	6.93	94
Kalma	0.13	0.14	0.10	1.16	5.17	6.70	77
Khadimnagar	0.15	0.21	0.11	1.18	5.47	6.46	85
Mirsarai	0.25	0.29	0.15	2.52	5.36	6.50	82
Noadda	0.18	0.18	0.10	0.60	3.58	8.07	44
Pirgacha	0.26	0.28	0.18	1.98	6.66	7.60	88
Ranisankail	0.27	0.28	0.19	2.41	6.80	8.12	84
Sonatala	0.14	0.17	0.09	1.15	5.08	6.50	78
Tejgaon	0.21	0.24	0.16	1.96	5.82	7.08	82

(b) for wheat (Kanchan) :

Soil series	Extractable K (meq%)				Rice yield (g d. m./kg)		RY (%)
	NH_4OAc	ASI	NaCl	HNO_3	No K	With K*	
Chandina	0.08	0.12	0.08	0.63	2.89	3.66	78
Chandra	0.06	0.10	0.06	0.50	2.61	3.61	72
Ghatail	0.13	0.14	0.10	1.98	3.37	3.48	97
Kalma	0.13	0.14	0.10	1.16	2.67	3.33	80
Khadimnagar	0.15	0.21	0.11	1.18	3.19	3.57	88
Mirsarai	0.25	0.29	0.15	2.52	3.01	3.25	93
Noadda	0.18	0.18	0.10	0.60	3.06	3.26	93
Pirgacha	0:26	0.28	0.18	1.98	3.42	3.81	90
Ranisankail	0.27	0.28	0,19	2.41	3.19	3.35	95
Sonatala	0.14	0.17	0.09	1.15	3.22	3.34	96
Tejgaon	0.21	0.24	0.16	1.96	3.21	3.46	93

* The maximum yield obtained for the level of potassium application (the rates at which the maximum yield was obtained varied from soil to soil).

The best correlation co-efficient was obtained between K_{AA} and K_{AS} ($r = 0.968$, $p = 0.001$) among all the extractants (Table 3).

Similar relationship between these two extractants for other soils have also been observed by others (7, 8). The strong relationship between the two extractants indicates that either of the two extractants could effectively be used for determining extractable soil-K (15).

Table 3. Correlation coefficients (r) and simple regression equations among the four K-test methods.

Soil K-test methods	Correlation Coefficient (r)	Regression equation
NH_4OAc and ASI	0.968 (p = 0.001)	K_{AS} = 0.037 + 0.932 K_{AA}
NH_4OAc and NaCl	0.951 (p = 0.001)	K_{NaCl} = 0.023 + 0.571 K_{AA}
NH_4OAc and HNO_3	0.807 (p = 0.001)	K_{NA} = 0.050 + 8.339 K_{AA}
ASI and NaCl	0.932 (p = 0.001)	K_{NaCl} = 0.006 + 0.581 K_{AS}
ASI and HNO_3	0.801 (p = 0.001)	K_{NA} = 0.217 + 8.587 K_{AS}
NaCl and HNO_3	0.839 (p = 0.001)	K_{NA} = 0.268 + 14.413 K_{NaCl}

Critical level of soil potassium. From the crop yields with and without added potassium and their corresponding per cent relative yields (Bray's per cent yield) as presented in Table 2 (a, b) it appeared that relative yields varied from 44% (Noadda) to 93% (Ghatail) for rice and 72% (Chandra) to 96% (Ghatail) for wheat. Following Cate-Nelson (13) graphical method, 0.072, 0.108, 0.09 and 0.66 meq% soil were observed as critical levels for K_{AA}, K_{AS}, K_{NaCl} and K_{NA} respectively for wetland rice (Fig. 1, a-d) while for wheat the respective values were 0.102, 0.126, 0.084 and 0.54 meq% soil (Fig. 2, a-d).

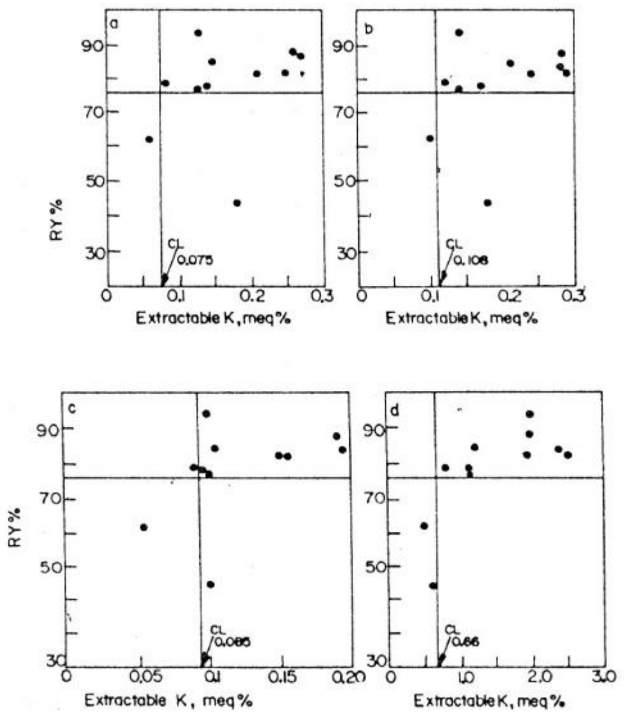

Fig. 1. Critical level of soil potassium for low-land rice by Cate-Nelson graphical method. (a) NH_4OAc method; (b) ASI method; (c) 1M NaCl method and (d) boiling 1N HNO_3 method.

Statistical procedure (14) was also employed to find the critical levels of soil-K for the same extractants (Table 4a, b). It is apparent from Table 4 that the statistical method yielded almost similar values as were obtained for the graphical methods.

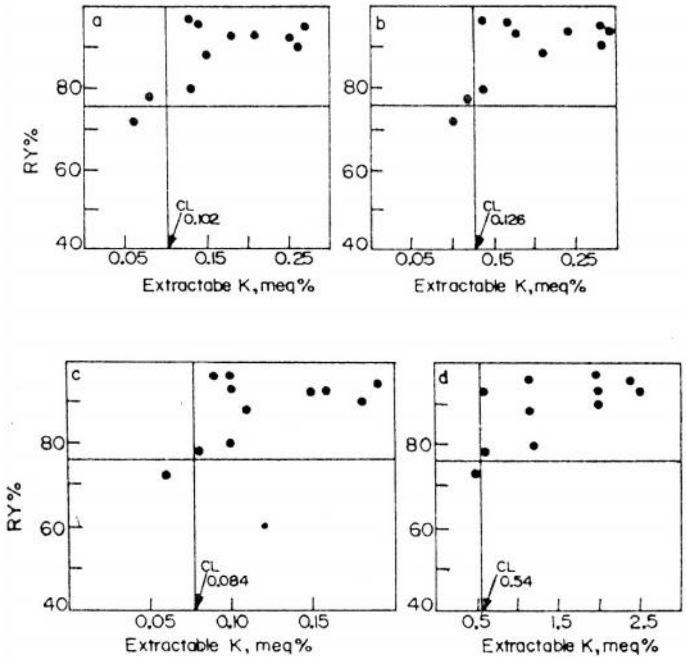

Fig. 2. Critical level of soil potassium for upland wheat by Cate-Nelson graphical method. (a) NH_4OAc method; (b) ASI method; (c) 1M NaCl method and (d) boiling 1N HNO_3 method.

For wetland rice, the highest R^2 value (Table 4a) was found for boiling 1N HNO_3 method (0.80). This extractant could be taken the best for predicting K-response of wetland rice. Similar conclusion was also drawn by others (16-18). For wheat (Table 4b) the highest value was observed for K_{AA}, K_{AS} and K_{NaCl} (0.66). It appears that all these three extractants were equally suitable for predicting K-response of upland wheat. Similar observation have also been made by Kumar and Jha (19), Rao *et al.* (20) and Kumar *et al.* (21). Saleque *et al.* (10) working at 11 different locations found 0.075 and 0.067 meq% soil K as the critical level for K_{AA} and K_{AS} respectively for wetland rice. BARC (1) reported 0.1 meq% soil potassium as the critical level for K_{AS} for wetland rice. Bhuyian *et al.* (7) also found 0.1, 0.075 and 1.125 meq% soil K for K_{AA}, K_{AS} and K_{NA} respectively.

Boiling 1N HNO_3 extraction appears to be better either than the ASI, NH_4OAc or 1M NaCl (pH 3.0) for wetland rice while for wheat the latter three extractants were better than the boiling 1N HNO_3.

In the present investigation a number of critical level values for soil-K as extracted by different extractants have been found for wetland rice and upland wheat crops. It has also been observed that the values for critical level of soil-K

Table 4. Critical soil potassium levels by various methods as determined by the graphical and statistical methods for the soils under study.

(a) for rice

Soil K test methods	Methods for determining critical K levels		R^2
	Graphical (meq %)	Statistical (meq%)	
1N NH_4OAc	0.072	0.070	0.15
ASI	0.108	0.110	0.15
1M NaCl (pH 3.0)	0.090	0.105	0.15
1N NHO_3 (boiling)	0.660	0.620	0.80

(b) For wheat

Soil K test methods	Methods for determining critical K levels		R2
	Graphical (meq %)	Statistical (meq%)	
1NN H_4OAc	*0.102*	*0.105*	*0.66*
ASI	0.126	0.130	0.66
1M NaCl (pH 3.0)	0.084	0.084	0.66
1N HNO_3 (boiling)	0.540	0.550	0.44

for K_{AA} and K_{AS} for wheat are higher than that found for wetland rice. These values can effectively be used to differentiate soils as to the K-responsiveness from K non-responsiveness. It indicates that crop yield will respond strongly to applied K on those soils where the extractable-K level is very close to or below the critical level observed and be of great help in a rational K-fertilization programme for crops. Accordingly, all soils except Ghatail, Kalma and Noadda fall in the K-responsive category.

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