



# Potassium Depletion in Rice Cultivation: Insights from a Pot Culture Study in Bangladesh

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## Abstract

A pot culture experiment was conducted in the greenhouse of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, using eleven soil series of Bangladesh in order to see the depletion behaviour of potassium (K) by continuous cropping using rice (var. Iratom-24) as the test crop. The soil series were Ranishankhail, Kaonia, Sonatala, Silmondi, Gopalpur, Ishurdi, Sara, Kongsha, Nunni, Lautu and Amnura on which four successive rice plants (45 days duration) were raised with (100 ppm K) or without addition of potassium. Nitrogen, phosphorus, sulfur and zinc were applied as basal to all pots. Potassium application resulted in higher dry matter yield, increased K concentration and uptake in all the soils compared with no K treatment, which gradually decreased in the subsequent harvests. Plant takes up K not only from exchangeable pool but also from non-exchangeable sites. A minimum replenishment of K from the soil reserve was observed. Continuous cropping has resulted in the depletion of available K of the soil. The result indicated that in order to sustain higher crop yield under intensive cultivation, the addition of potash fertilizer is necessary.

## Subject Areas

Agricultural Science

## Keywords

Potassium, Exchangeable Pool, Depletion Behavior

## 1. Introduction

Yield of a crop is a function of many factors of which nutrients play a great role. Soil is the primary source of such nutrients. But intensive crop culture with high cropping intensity-initiated problems with the supply of nutrients from soil. The continuous application of potassic fertilizer may have pronounced effect on dynamics of added K. One of the most often used potassium fertilizers is potassium salt 60% NOD, which is potassium chloride with a 60%  $K_2O$  concentration. One of the key elements promoting plant growth is potassium. It also raises crop fertility, which is linked to a faster rate of photosynthesis. Utilizing the potassium salt included in our service makes the plants more resistant to disease and lodging. Additionally, they become more drought resistant. It is an extremely concentrated, high-performing fertilizer that works well on nearly all soil types and with virtually all crops (with the exception of tobacco, hops, berries, and some vegetables). Distribution of K into different forms as a consequence of long-term fertilization plays a significant role in determining the availability of K to the crops [1]. Potassium deficiencies can develop in soils testing in sufficient to high range, soil pH < 5.8, soils overloaded with  $Ca^{2+}$  ions or in cases where soils are oxygen deprived. At pH < 5.8  $H^+$  ions begin to occupy cation exchange sites (CE-sites), making it difficult for potassium to find places to attach.

Plants absorb large amounts of potassium, all of it in the form of the  $K^+$  ion. The positive charges of the K cations help to maintain electrical neutrality in both soil and plants by balancing the negative charges of nitrate, phosphate and other anions [2]. Plants required relatively large amounts of K and often can use more than the soil can supply. Soil K has prodigious impacts. It helps in the development of a strong and healthy root system and increases the efficiency of the uptake and use of nitrogen and other nutrients. It also increases the plant resistance to diseases and pests. Owing to the lack of potassium, photosynthesis decreases but respiration increases, resulting decreased the production of carbohydrate. Application of K at an optimum level promoted photosynthesis,  $CO_2$  assimilation and the translocation of photosynthates to grains and promoting high grain yield [3]. Potassium release refers to the replenishment of the readily available K removed either by crops or by chemical extractants. Released K, is the sum of exchangeable and water-soluble potassium that is ready for plants. Non-exchangeable or fixed K could be released exchangeable and soluble forms when the latter to become depleted. One of the most often used potassium fertilizers is potassium salt 60% NOD, which is potassium chloride with a 60%  $K_2O$  concentration.

Older soils releasing power of non-exchangeable and exchangeable K become gradually poor and depleted.

To overcome this depletion, some studies showed that organic materials could improve the physicochemical properties of continuous cropping soil, increase the diversity of microbial community structure in soil, inhibit the reproduction of pathogenic microorganisms in soil, and reduce the accumulation of toxic substances in soil [4]. Realizing the importance of potassium, a pot experiment was

carried out by using rice plants with different soil series under the heading of “Potassium Depletion in Rice Cultivation: Insights from a Pot Culture Study in Bangladesh” for fulfilling the following objectives: 1) To evaluate the K supplying power of soils, crop response to applied K and the efficiency of its uptake from soils and 2) K uptake from both exchangeable and non-exchangeable soil sites was observed.

## **2. Materials and Methods**

### **2.1. Experimental Site and Soils**

The experiments were conducted at the Soil Science Laboratory and greenhouse of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during the period from March 2004 to October 2004. Eleven top soils (0 - 15 cm) of eleven soil series used in this study were Ranishankhail of AEZ1; Kaonia of AEZ3; Sonatola and Silmondi of AEZ9; Gopalpur, Ishurdi and Sara of AEZ11; Kongsha and Nunni of AEZ22; Lautala and Amnura of AEZ28, respectively. Soil series were identified and selected with the help of the scientific personnel of the Soil Resource Development Institute (SRDI) at respective districts.

### **2.2. Pot Culture Experiment**

For each soil series, 5 kg of soil was taken in each of six plastic pots with normal packing and allowed to soak with deionised water for a couple of days. Each of the pots was marked with treatments and soil series. Pots were placed at random.

### **2.3. Test Crop**

The test crop under study was rice. The variety was Iratom-24.

### **2.4. Treatment**

Two levels of potassium with three replications were used for each soil. The K levels were:

- 1)  $K_0$  (No potassium);
- 2)  $K_{100}$  (100 ppm potassium).

Hundred ppm (100 ppm) nitrogen, 80 ppm phosphorus, 40 ppm sulphur and 10 ppm zinc were applied as basal dose in all pots.

### **2.5. Application of Fertilizer**

All the pots were fertilized by adding solution to provide 100 ppm N, 80 ppm P, 40 ppm S and 10 ppm Zn. Potassium in solution was added in the treated pots at the rate of 100 ppm (soil basis) and the untreated pots were left without addition of K. After each harvest 100 ppm N, 80 ppm P, 40 ppm S and 100 ppm K (except  $K_0$  pot) was added to each pot.

### **2.6. Planting**

Selected healthy seeds of rice (Iratom-24) were placed on blotting paper in Petri

dishes (Dapog method). The sprouted seeds were then sown in the pot and after establishment, six seedlings were kept in each pot to grown up to harvest.

### **2.7. Intercultural Operation**

During the growth period, intercultural operations, including watering with de-ionized water and weeding etc., were done as per requirement.

### **2.8. Harvesting**

The plants were harvested after forty-five days of planting. After harvesting, the dry matter yields due to K treatments were recorded. The dried samples were then grounded in a stainless-steel Wiley mill to pass through a 20-mesh sieve. Then, the samples were ready for chemical analysis.

### **2.9. Repetition of the Experiment**

After harvest, dry leaves and weeds were removed from all pots. The experiment was set up again with the same soil and pot. Successive three harvests were made following the first harvest. Nitrogen, phosphorus, sulfur and potassium (except K<sub>0</sub> pot) was added to each pot in case of second, third and fourth harvests.

### **2.10. Post-Harvest Soil Collection**

The soils were collected from every pot after each harvest. The soils were processed for K status in post-harvest soils of each series.

### **2.11. Plant Sample Collection**

Plant samples were collected from harvested pots and analyzed for the determination of N, P, and K content, as described above.

### **2.12. Physical and Chemical Analyses of Soil and Plant Samples**

The collected soil samples were analyzed for both physical and chemical properties in the laboratory of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Mechanical analysis was done by the hydrometer method as described by [5]. Soil pH was measured with the help of glass electric P<sup>H</sup> meter using soil water suspension of 1:2.5 [6]. Organic carbon in soil was determined by wet oxidation method [7]. The total nitrogen of soil was determined by the micro Kjeldahl Method. Available soil phosphorus was measured by Olsen method. Exchangeable potassium was extracted from each soil sample by 1N NH<sub>4</sub>OAC and determined using a flame photometer [8] and available sulfur was determined by turbidimetric method [5]. The collected plant samples from each pot were dried in an oven at 65°C for 48 hours and were ground by a grinding mill. Then the ground samples were sieved through 20 mesh sieves. The prepared samples were then chemically analyzed for N, P, K and S following di-acid digestion procedure [9] [10]. The analysis of variance for crop characters and also for the nutrient elements of plant samples were done following F-test. Mean comparisons

of the treatments were made following Duncan's Multiple Range Test (DMRT).

### 3. Results and Discussion

A pot culture experiment was conducted under greenhouse conditions using eleven soil series, from different AEZ of Bangladesh on which four successive rice crops (45 days duration) were raised with or without the addition of potassium with a view to study the depletion behavior of native and applied potassium.

Data on dry matter yield and K concentrations of rice plants in different soil series as influenced by potassium treatment are presented in **Table 1** and **Table 2**.

#### 3.1. Effect on Dry Matter Yield

The K treatments imposed on different soils markedly affected the dry matter production of rice in four harvestings (**Table 1**). In the first harvest, yield increase due to K addition ranged from 0.3% in soil of the Gopalpur series to 20.0% in soils of Ranishankail and Sara series. On average, the yield increase due to K addition was 10.8% over the soils without K addition. In the second harvest, on average, the yield increase with K application was 20.3% over without K addition. Similarly, the average yield increase with K application in third and fourth harvests were 13.4% and 22.7%, respectively. The dry matter yields of Ranishankhail series were 7.18 g-pot<sup>-1</sup> and 2.49 g-pot<sup>-1</sup> in first and fourth harvest without any K application, while with K addition the yields were 8.62 g-pot<sup>-1</sup> and 2.50 g-pot<sup>-1</sup>, respectively. It appears that the crop suffered from K availability in soils. The rice yields in the second harvest of all the soils with 100 ppm K application were lower compared to the yield obtained without K application in the first harvest. Therefore, K availability might have limited the rice yields in subsequent harvests. The noticeable influence of added K was also reported by many investigators [11]-[16].

#### 3.2. Effects on N and P Concentration in Plant

Nitrogen and phosphorus concentration in the K treated plants were higher than that received no K fertilizer. In case of nitrogen in the first harvest, the concentration increase due to K addition was 1.49% over the soils without K addition on an average. In the 2<sup>nd</sup> harvest, the concentration increases with K application (+K) pots showed a concentration by 1.20% in Kongsha soil to 1.63% in soil of Silmondi series. Similarly, the average concentration increases with K application in third and fourth harvests were 1.13% and 0.87% respectively.

In case of phosphorus, in the first harvest, the concentration increase due to K addition was 0.08% over the soils without K addition, on average. In the 2<sup>nd</sup> harvest, the concentration increases with K application (+K) pots showed the concentration by 0.05% in Kaonia, Silmondi and Sara soil to 0.08% in soil of Gopalpur series over control. Similarly, the average concentration increases with K application in third and fourth harvests were 0.05% and 0.03%, respectively. [17] stated that N and K content declined over 6 years, even at high N and K rates. Similarly,

average concentrations of P in rice plant declined from 0.08% to 0.03% in the K treated pot and 0.07% to 0.02% in K-untreated pot for the four subsequent harvests. A similar noticeable influence of added K was also reported by [16].

### 3.3. Effect on K Concentration in Plant

In the first harvest, on an average, the concentration increase due to K addition was 1.41% over the soils without K addition. In the 2<sup>nd</sup> harvest, the concentration increases with K application (+K) pots showed the concentration by 1.05% in Silmondi soil to 1.48% in soil of Ranishankhail series over control. Similarly, the average concentration increases with K application in third and fourth harvests were 1.26% and 1.19%, respectively. Average concentration of K in rice plant tissue declined from 1.41% to 1.19% in the K treated pot and from 1.34% to 1.14% in K untreated pot for the four subsequent harvests. [12] reported K concentration in plants declined from 0.7 to 1.3 percent to 0.4 - 0.5 at the 3<sup>rd</sup> or 4<sup>th</sup> harvest. Similar results were also observed by [18]. The effect of K-on-K concentration in plant tissue was comparatively more remarkable for the first crop and the difference reduced after 3<sup>rd</sup> harvest (Table 2).

### 3.4. Effects on N and P Uptake

The corresponding N uptake by the plant was 113.70 mg/pot (1<sup>st</sup> harvest) to 18.64 mg/pot (4<sup>th</sup> harvest) in K untreated pot. Similarly, the mean value of P uptake decreased from 7.29 mg/pot (1<sup>st</sup> harvest) to 0.97 mg/pot (4<sup>th</sup> harvest) in the K treated pot and K untreated pot. Phosphorus uptake decreased from 5.80 mg/pot in the 1<sup>st</sup> harvest to 0.59 mg/pot in the 4<sup>th</sup> harvest. [17] reported from a field experiment with two upland rices, and it was found that the total dry matter yield and the uptake of P and K by the crop at harvest increased due to N application.

### 3.5. Effect on K Uptake

Potassium uptake by plant followed more or less similar trend as observed in dry matter yield. Potassium uptake was higher in Amnura soil series (144.71 mg/pot) and lower in Silmondi soil series (95.02 mg/pot) (Table 3). The uptake of K was continually decreased as dry matter yield at the subsequent harvests. The higher K uptake due to its application is evidenced by the results of many earlier observations [12] [19] and [15].

### 3.6. Exchangeable/Available K

Both exchangeable and available K tended to decline with the subsequent harvests in both K treated and untreated soil. Potassium application had significant effect on available/exchangeable K of the post-harvest soil. Exchangeable K are being continually exhausted from the soil K reserve through crop removal and the replenishment towards it is minimum. The findings of the present work as also established by [20]. The extractable K declined with time where K fertilizer was not

applied. Intensive cropping for high yield caused heavy depletion on exchangeable K in alluvial soils, particularly in absence of K fertilizer.

**Table 1.** Dry matter yield (g/pot) of rice at subsequent harvest.

Soil series	1 <sup>st</sup> harvest		2 <sup>nd</sup> harvest		3 <sup>rd</sup> harvest		4 <sup>th</sup> harvest	
	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>
Ranishankhail	8.62 (20.0%)	7.18	7.89 (49.7%)	5.27	3.98 (20.6)	3.30	2.50 (0.4%)	2.49
Kaonia	9.70 (5.8%)	9.16	6.65 (20.9%)	5.50	5.39 (1.1%)	5.33	4.29 (36.6%)	3.14
Sonatala	10.13 (17.1%)	8.65	5.10 (4.9%)	4.86	3.94 (23.8%)	3.18	2.99 (20.5%)	2.48
Silmondi	8.56 (3.2%)	8.29	5.87 (4.7%)	4.82	4.80 (63.2%)	2.94	2.46 (4.6%)	2.35
Gopalpur	7.82 (0.3%)	7.80	6.54 (22.9%)	5.32	5.09 (3.0%)	4.94	2.58 (29.0%)	2.00
Ishurdi	10.88 (17.8%)	9.24	8.99 (37.0%)	6.56	5.00 (0.4%)	4.98	4.24 (18.4%)	3.58
Sara	7.21 (20.0%)	6.00	5.74 (24.7%)	4.60	3.98 (2.8%)	3.87	2.43 (21.5%)	2.00
Kongsha	6.45 (9.5%)	5.89	4.28 (0.2%)	4.27	3.99 (5.0%)	3.80	2.19 (38.6%)	1.58
Nunni	7.51 (12.0%)	6.70	5.58 (22.1%)	4.57	3.87 (29.4%)	2.99	1.58 (6.0%)	1.49
Lauta	9.74 (6.6%)	9.13	6.88 (7.6%)	6.39	4.39 (29.1%)	3.40	3.18 (26.1%)	2.52
Amnura	9.98 (9.5%)	9.11	6.05 (6.7%)	5.67	5.36 (1.3%)	5.29	4.87 (39.9%)	3.48
Mean	8.78 (10.8%)	7.92	6.32 (20.3%)	5.25	4.52 (13.4%)	4.00	3.02 (22.7%)	2.46

\*The value in the parentheses indicate yield increase over potassium (K) content.

**Table 2.** Potassium concentration (%) in rice plant at subsequent harvest.

Soil series	1 <sup>st</sup> harvest		2 <sup>nd</sup> harvest		3 <sup>rd</sup> harvest		4 <sup>th</sup> harvest	
	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>
Ranishankhail	1.50	1.39	1.48	1.33	1.37	1.28	1.27	1.22
Kaonia	1.47	1.41	1.38	1.27	1.32	1.24	1.20	1.19
Sonatala	1.11	1.08	1.08	1.01	1.01	0.98	1.00	0.96
Silmondi	1.11	1.04	1.05	1.05	1.00	1.97	1.05	1.00
Gopalpur	1.49	1.39	1.45	1.37	1.39	1.27	1.29	1.18
Ishurdi	1.52	1.41	1.29	1.22	1.28	1.20	1.26	1.17
Sara	1.36	1.34	1.32	1.27	1.26	1.23	1.17	1.15
<b>Kongsha</b>	<b>1.53</b>	<b>1.44</b>	<b>1.39</b>	<b>1.37</b>	<b>1.30</b>	<b>1.27</b>	<b>1.21</b>	<b>1.19</b>

## Continued

Nunni	1.45	1.41	1.32	1.33	1.28	1.22	1.17	1.15
Lauta	1.50	1.49	1.39	1.38	1.29	1.27	1.20	1.14
Amnura	1.45	1.39	1.40	1.35	1.34	1.30	1.27	1.24
Mean $\pm$ SD	1.41 $\pm$ 0.154	1.34 $\pm$ 0.145	1.32 $\pm$ 0.139	1.27 $\pm$ 0.128	1.26 $\pm$ 0.131	1.20 $\pm$ 0.116	1.19 $\pm$ 0.092	1.14 $\pm$ 0.087

**Table 3.** Potassium uptake (mg/pot) of rice at subsequent harvests.

Soil series	1 <sup>st</sup> harvest		2 <sup>nd</sup> harvest		3 <sup>rd</sup> harvest		4 <sup>th</sup> harvest	
	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>	K <sub>100</sub>	K <sub>0</sub>
Ranishankhail	129.30	99.80	116.77	70.09	54.53	42.24	31.75	30.38
Kaonia	142.59	129.16	91.77	69.85	71.15	66.09	51.48	37.37
Sonatala	112.44	93.42	55.08	49.09	39.79	31.16	29.90	23.81
Silmondi	95.02	86.22	61.64	50.61	48.00	28.52	25.83	23.50
Gopalpur	116.52	108.42	94.83	72.88	70.75	62.74	33.28	23.60
Ishurdi	116.52	108.42	94.83	72.88	70.75	62.74	33.28	23.60
Sara	98.06	80.40	75.77	58.42	50.15	47.60	28.43	23.00
Kongsha	98.69	84.82	59.49	58.50	51.87	48.26	26.50	18.80
Nunni	108.90	94.47	73.66	60.78	49.54	36.48	18.49	17.14
Lauta	146.10	136.04	95.63	88.18	56.63	43.18	38.16	28.73
Amnura	144.71	126.63	84.70	76.55	71.82	68.77	61.85	43.15
Mean	118.99	104.35	82.20	66.17	57.73	48.89	34.45	26.64

## 4. Conclusion

From the present study, it may be concluded that the intensive continuous cropping for high yield caused heavy depletion of both exchangeable and extractable K, which are continually replenished from the soil K reserves after being removed by the crops. Thus, to maintain the potassium removal by the crops from the soils, adequate use of potassium is necessary to sustain crop production. The results underscore the necessity of potash fertilizer to maintain high crop yields in intensive agricultural practices in Bangladesh's diverse soil types.

## Conflicts of Interest

The authors declare no conflicts of interest.

## References

- [1] Setia, R.K and Sharma, K.N. (2004) Vertical Distribution of Chemical Pools of Potassium and Their Relationship with Potassium Nutrition of Rice under Long-Term Differential Fertilization. *Journal of the Indian Society of Soil Science*, **52**, Article 470.
- [2] Fontes, M.P.F. and Alleoni, L.R.F. (2006) Electrochemical Attributes and Availability of Nutrients, Toxic Elements, and Heavy Metals in Tropical Soils. *Scientia Agricola*,

- 63, 589-608. <https://doi.org/10.1590/s0103-90162006000600014>
- [3] Rao, M.H. and Subramanian, T.R. (1990) Depletion and Build up of Soil Potassium as Affected by Varying Levels of Potassium and Different Vegetable Cropping Sequences in an Alfisol. *Journal of Potassium Research*, **6**, 29-35.
- [4] Gao, Z.Q. and Zhang, S.X. (1998) Continuous Cropping Obstacle and Rhizospheric Microecology I. Root Exudates and Their Ecological Effects. *Chinese Journal of Applied Ecology*, **9**, 549-554.
- [5] Page, A., Miller, R.H. and Keeney, D.R. (1989) Methods of Soil Analysis. Part 2. 2nd Edition. American Society of Agronomy.
- [6] Jackson, M.L. (1962) Soil Chemical Analysis. Prentice Hall Inc.
- [7] Walkley, A. and Black, I.A. (1934) An Examination of the Degtjareff Method for Determining Soil Organic Matter, and a Proposed Modification of the Chromic Acid Titration Method. *Soil Science*, **37**, 29-38.  
<https://doi.org/10.1097/00010694-193401000-00003>
- [8] Black, C.A. (1965) Methods of Soil Analysis Part II. Agron. Series 9. American Society of Agronomy.
- [9] Jones, J.B. and Case, V.W. (1990) Sampling, Handling, and Analyzing Plant Tissue Samples. In: Westerman, R.L., Ed., *Soil Testing and Plant Analysis*, Soil Science Society of America, 389-427. <https://doi.org/10.2136/sssabookser3.3ed.c15>
- [10] Watson, M.E. and Isaac, R.A. (2018) Analytical Instruments for Soil and Plant Analysis. In: Westerman, R.L., Ed., *Soil Testing and Plant Analysis*, Soil Science Society of America, 691-740. <https://doi.org/10.2136/sssabookser3.3ed.c26>
- [11] Haque, S.A., Bhuiya, Z.H., Habibullah, A.K.M., Ali, M.I., Choudhury, F.A., Uddin, M.J. and Rahman, M.M. (1981) Response of HYV Paddy to Potash Fertilization in Different Regions of Bangladesh. *Phosphorus and Potassium in the Tropics*, Kuala Lumpur, 17-19 August 1981, 425-431.
- [12] Chakravorti, S.P., Biddappa, C.C. and Patnaik, S. 1987. Dynamics of Potassium in Submerged Soils Growing Rice (*Oryza sativa* L.) 1. Influence of Continuous Cropping on Dry Matter Production and Potassium Nutrition of the Plant. *Journal of Potassium Research*, **3**, 98-106.
- [13] Ghosh, S.C. (1989) Potassium Depletion of Some Soils by Continuous Cropping. Master's Thesis, Bangladesh Agricultural University.
- [14] Mian, M.U., Ali, M.I., Karim, Z., Habibullah, A.K.M. and Valentine, K. (1991) Potash Research in Bangladesh. BARC, Dhaka. Soils Publication No. 35, 34.
- [15] Islam, M.S., Ali, M.I., Jahiruddin, M., Haque, M.Q. and Rahman, M.H. (1997) Potassium Release and Depletion Behaviour in Several Soils of Bangladesh. *Bangladesh Journal of Nuclear Agriculture*, **13**, 27-35.
- [16] Mukul, M.S.R. (2003) Release and Depletion Behaviour of Potassium by Continuous Cropping Using Para Grass as a Test Crop. Master's Thesis, Bangladesh Agricultural University.
- [17] Singh, M., Singh, M.P., Singh, Y. and Gupta, G.R. (1988) Long Range Effect of Continuous Rice Wheat Cropping under Varying Levels of N, P and K on Yield and Fertility Status of Soil with Particular Reference to Iron. *Journal of Plant Nutrition*, **11**, 1471-1478. <https://doi.org/10.1080/01904168809363903>
- [18] Ali, M.S., Karim, M.Y.A. and Chowdhury, A.K. (1980) A Study on Interionic Correlations in IRRI Strains of Rice. *Bangladesh Journal of Nuclear Agriculture*, **5**, 35-47.
- [19] Swarup, A. and Singh, K.N. (1987) Movement of Potassium in a Sodic Soil Profile as

Influenced by Long Term Use of Inorganic Fertilizer under Rice-Wheat Rotation. *Journal of the Indian Society of Soil Science*, **35**, Article 253.

- [20] Tiwari, K.N. (1985) Changes in Potassium Status of Alluvial Soils under Intensive Cropping. *Fertilizer News*, **30**, 17-24.