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POTASSIUM INDEXING OF SUMMER RICE GROWN IN THE SHALLOW TUBE WELL COMMAND AREAS OF CENTRAL BRAHMAPUTRA VALLEY ZONE OF ASSAM, INDIA

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ABSTRACT

Plant samples from summer rice crop and corresponding surface soil samples (0-15 cm) were collected from farmer's fields of Shallow Tube Well command areas of Central Brahmaputra Valley Zone, Assam. Analysis of soil and plant samples revealed widespread potassium deficiency in soil and rice crop. The average 1 *N* NH_4OAc extractable K in the soils of different agricultural sub-divisions of the zone varied from 48 to 63 mg kg^{-1} and rated as low as per the nutrient index, except Kaliabar sub-division. On an average, 28 and 58% rice plants grown in the zone were categorized as moderately and extremely deficient in potassium respectively. Potassium deficiency was observed despite higher amount of non- exchangeable K (812 – 1598 mg kg^{-1}) content in the soils.

Key words: Available K, Potassium indexing, Reserve K, Summer rice.

INTRODUCTION

The area under summer rice, locally known as *boro* rice, is increasing in the Central Brahmaputra Valley Zone of Assam. Now, *boro* rice followed by winter rice became the dominant production system in the zone. The area of *boro* rice presently under Shallow Tube Well (STW) command is about one lakh ha with an average productivity of 4.0 ton ha^{-1} and contributes more than 25% to the total food grain production of the zone. With the increase in area and use of high yielding varieties, potassium removal by rice crop has increased manifold in the recent years. Summer rice received the highest share of the total fertilizer consumed in the zone. However, potassium deficiency frequently appeared despite application of potassium fertilizers. It indicated that soils may be low in potassium and the applied quantity may not be sufficient to plants demand or potassium is not adequately available to plant due to its complex behaviour in these acid soils. Evaluation of soil potassium status alone may not be sufficient to address this problem. Analysis of potassium in plant is also necessary as it reflects the actual availability of soil potassium to the growing crop (Srinivasa Rao *et al.*,2000). The present investigation was therefore initiated to gather information on the status of potassium both in soil and rice plants grown in the zone.

MATERIALS AND METHODS

The study area located between $25^0 45^/$ to $26^0 45^/$ N latitude and $91^0 50^/$ to $93^0 20^/$ E longitude with a geographical area of 5535 sq km. The zone, consists of Nagaon and Morigaon districts having an annual average rainfall of 1800 mm. Net cultivated area of the zone is 3,19,000 ha with a cropping intensity of 198%. Average nutrient consumption is 72.8 kg ha^{-1}, which is quite higher than the state average (63.5 kg ha^{-1}).

During 2008, one hundred and two samples of summer rice plant (top two leaves at PI stage) along with equal numbers of corresponding surface soil sample (0-15 cm) were collected from farmers fields covering the entire STW command area of the zone. Plant samples were washed in distilled water, dried in hot air oven at 65^0C to constant weight. Dried samples were ground to pass through a 1 mm sieve and required amount were digested in

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a mixture of HNO_3: $HClO_4$ (3:1). Potassium in the digested materials was determined flame photometrically (Jackson, 1973). Soil samples were processed (< 2 mm) and analyzed for pH (1:2.5 soil water suspension), CEC, organic carbon, particle-size distribution, and 1*N* NH_4OAc extractable K following standard procedures. Boiling 1*N* HNO_3 extractable K was measured according to the procedure described by Knudsen *et al.* (1982).

The grouping of plant and soil samples in to various categories based on their K concentration and 1*N* NH_4OAc extractable K was made as per the ranges described by Singh and Bansal (2009). Rice plants those showed a concentration less than 1.1% was considered as extremely deficient, 1.1 to 1.3% as moderately deficient and above 1.3% as sufficient in potassium. Accordingly, soils contained less than 55 mg kg^{-1} were rated as low, 55 – 110 mg kg^{-1} as medium and those having greater than 110 mg kg^{-1} were categorized as high in available K status. Nutrient Index Value was calculated as

$$\text{Nutrient index value} = \frac{\%\ \text{Samples low} \times 1 + \%\ \text{Samples medium} \times 2 + \%\ \text{Samples high} \times 3}{100}$$

Nutrient Index Value below 1.66 was considered low, between 1.66 and 2.33 as medium and above 2.33 as high for overall status of potassium (Singh and Bansal, 2009).

RESULTS AND DISCUSSION

General characteristics of soils: The important physical and chemical properties of soils are presented in Table 1. Soils were sandy loam to clay loam in texture and strongly to extremely acidic in nature. Organic carbon was found invariably high (> 0.75%) in all the soils. High weed growth in the rice field under hot and humid climatic condition and subsequent *in-situ* decomposition of weed biomass might have enhanced the organic carbon content of these soils. The cation exchange capacity of the soils ranged from 6.3 to 13.2 cmol(P^+)kg^{-1} and found to be related with clay and its mineralogy and organic matter content of the soils.

Potassium status of the soils: Different forms of potassium in soils are presented in Table 2. Water soluble K of these soils varied from 3 mg kg^{-1} to 17 mg kg^{-1} in soils of Kaliabar sub-division. However as per the mean value (7 – 10 mg kg^{-1}), no significant

TABLE 1: Relevant soil properties.

Agricultural Sub-division	Particle-size distribution (%)						Texture*	pH	OC (%)		CEC [cmol(P^+)kg^{-1}]	
	Sand		Silt		Clay							
	Mean	Range	Mean	Range	Mean	Range		Range	Mean	Range	Mean	Range
Nagaon	36.8±13.1	14.2-54.7	33.0±10.9	19.9-57.2	30.2+6.7	15.6-38.2	sl-cl	4.1-5.6	1.67±0.26	1.22-2.18	9.2±1.6	6.5-13.2
Kaliabar	40.3±8.3	23.3-52.9	27.6±7.2	17.5-40.6	32.1±9.7	14.5-40.8	sl-cl	4.2-5.8	1.57±0.25	1.22-2.19	9.5±1.2	7.5-12.2
Hojai	30.8±14.6	12.4-58.7	44.0±14.5	23.8-59.2	25.2±7.5	17.2-36.3	sl-sicl	4.1-4.8	1.97±0.29	1.62-2.45	8.2±1.1	6.3-9.5
Roha	41.3±12.8	16.2-51.9	28.0±9.1	20.5-53.0	30.7±3.1	26.2-36.4	scl-sicl	4.6-5.2	1.50±0.20	1.26-1.85	9.5±1.4	7.5-11.7
Marigaon	29.0±14.2	19.5-52.8	39.1±12.9	17.2-57.2	31.9±7.1	18.4-43.7	scl-si1	4.2-5.6	1.34±0.15	1.12-1.64	10.4±2.0	7.5-12.9

*sl : sandy loam ;cl: clay loam; scl: sandy clay loam; sil : silt loam; sicl : silty clay loam

TABLE 2 : Different forms of soil potassium.

Agricultural Sub-divisions	Water soluble K		1 N NH4OAc-K		1N HNO3-K		Exchangeable K	Non-exchangeable K	Rating of soils based on 1 N NH4OAc-K (% samples)			NIV based on 1 N NH4OAc-K
	(mg kg^{-1})											
	Mean ±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Mean±SD	Low	Medium	High	
Nagaon	8±3	4-15	54±10	38-72	1130±329	664-2004	46±11	1076±326	54	46	-	1.46 (L)*
Kaliabar	10±4	3-17	63±18	36-110	1048±390	572-2126	53±16	985±384	32	64	4	1.72 (M)
Hojai	7±2	5-11	48±9	37-65	860±72	727-963	41±9	812±70	83	17	-	1.17 (L)
Roha	7±3	3-14	53±16	32-93	1119±285	776-1620	46±15	1067±282	67	33	-	1.33 (L)
Marigaon	8±3	3-14	51±9	34-66	1649±268	1092-2122	43±9	1598±263	64	36	-	1.36 (L)

L : Low M: Medium

difference was observed among the different sub-divisions. 1 *N* NH_4OAc extractable or available K showed wide variation (32-110 mg kg^{-1}) in these soils. Considering the mean values, the highest available K was recorded in Kaliabar (63 mg kg^{-1}) and lowest in Hojai (48 mg kg^{-1}). Available K exhibited significant and positive relationship with organic carbon (r = 0.19*) and CEC (r = 0.21*) and highly significant with clay content (r = 0.32**) in these soils. Thus it indicated that the finer fraction of these soils is the main reservoir of available K. A perusal of the values of exchangeable K indicated an identical distribution pattern with available K in the soils. Potassium status of soils of all the five sub-divisions was categorized in to low, medium and high based on the content of 1 *N* NH_4OAc extractable K. Baring Kaliabar, soils of all the other four sub-divisions fall in low category as per the nutrient index value (NIV).

The soils of Kaliabar sub-division showed the large variation in boiling 1*N* HNO_3 acid extractable K (reserve K) having highest (2126 mg kg^{-1}) and lowest (572 mg kg^{-1}) one. The highest average mean value of reserve K was estimated in Morigaon (1649 mg kg^{-1}) followed by Nagaon. Reserve K also found to be influenced by clay fraction of these soils as indicated by significant and positive relationship between these two parameters (r= 0.21*). The least mean value in Hojai soils (860 mg kg^{-1}) could be ascribed to low clay content besides dominance of low activity clay like kaolinite. The presence of dioctahedral micas and least amount of vermiculite in the finer fraction might be the reason for higher value of 1*N* HNO_3 acid extractable K in the soils of Morigaon and Nagaon sub-division (Dutta and Shanwal, 2006). Non-exchangeable K (1*N* HNO_3 acid extractable K- 1 *N* NH_4OAc extractable K) exhibited the same distribution pattern as in reserve K in these soils. The non -significant relationship between available and reserve K in these soils reflected a weak dynamic equilibrium that might adversely affect the replenishment of solution potassium.

Potassium status of Summer rice crop: Rice plants had wide variation in their K concentration (Table 3). Plant samples collected from Nagaon showed maximum variation in K concentration (0.59 – 1.96%) and highest mean K concentration was also recorded in this sub-division (1.12%). The

TABLE 3 : Potassium indexing of summer rice.

Agricultural Sub-division	K concentration range (%)	K concentration Mean ± SD (%)	Rating of samples based on plant K concentration (% samples)		
			Sufficient	Moderately deficient	Extremely deficient
Nagaon	0.59-1.96	1.12± 0.37	29	21	50
Kaliabar	0.66-1.94	1.10± 0.37	24	12	64
Hojai	0.62-1.31	0.95± 0.21	8	25	67
Roha	0.84-1.34	1.07± 0.15	7	40	53
Marigaon	0.66-1.31	1.02± 0.18	4	42	54

lowest mean value was observed in Hojai (0.95%). Grouping of plants into different categories based on plant K concentration revealed wide spread deficiency of potassium in summer rice grown in entire zone. More than 50% plant samples in all the sub-division were found extremely deficient in potassium and 12-42% plants categorized as moderately deficient. Only 4-8% plants were found sufficient in potassium in Hojai, Roha and Morigaon. However, relatively higher numbers of plants were categorized as sufficient in Nagaon and Kaliabar sub-division, i.e. 29 and 24% respectively.

Soil potassium *versus* potassium in rice plant: The highest potassium deficiency of rice plants grown in Hojai (67%) was attributed to low available and non-exchangeable K content of soil. It was observed that, despite having highest nutrient index value, 64% plant samples were found extremely deficient in Kaliabar sub-division. On the other hand, considerably higher amount of plant samples (24%) were also recorded as sufficient in this subdivision. A perusal of data on amount of clay, available and reserve K content of Kaliabar indicated large variation that might have affected the plant available K . It implies that the light textured soils of the area was unable to maintain a satisfactory level of solution K resulting in potassium deficiency than the heavy textured soils. The magnitude of potassium sufficiency was higher in Nagaon sub-division (29%). The relationship between available and reserve K was significant and positive in soils of Nagaon (r= 0.42*). It suggested that contribution from non-exchangeable pool of soil K may be responsible for such variations in Nagaon sub-division. The trend of potassium deficiency was almost similar in Roha and Morigaon sub-division. The soils of both sub-division had comparable amount of mean available K and also showed similar nutrient index value. Though soils of Morigaon contained higher amount of HNO_3-K than Roha, but due to weak dynamic equilibrium between available and reserve K, the rate of replenishment from the reserve pool might not be sufficient to meet the crop demand for potassium. Slow release behaviour of reserve K in soils of Assam was also reported by Baruah *et al.* (1996).

On an average, 86% of the rice plant samples were deficient in potassium (deficient, 28% and extremely deficient, 58%). The widespread potassium deficiency might also be ascribed to low temperature during the early growing stages of summer rice as cumulative K adsorption decreased with temperature (Hundal and Pasricha, 1994 and 1998). Besides, a considerable portion of K becomes unavailable due to leaching and fixation. It has been reported that 28 to 90% of the added potassium was fixed in soils of Assam which significantly reduce the plant available K (Baruah *et al.* 1991). The both processes of fixation and leaching were highest under rice cultivation due to high water content and alternate wetting and drying condition of rice fields.

Keeping in view the large scale deficiency of potassium in summer rice crop grown in central Brahmaputra valley zone, it appears that available K of these soils is insufficient to meet the crop demand. The inadequacy of available K was further aggravated by poor dynamic equilibrium between available and reserve K. The findings indicated that the existing recommended dose (30 kg K_2O ha^{-1} as basal) for summer rice is not adequate to meet the crop requirement. Considering the other factors like leaching and fixation of added K, evaluation of suitable application timing involving split application of potassium fertilizer is also necessary in order to maintain a satisfactory level of potassium throughout the growing stages of summer rice.

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