POTASSIUM RELEASE POTENTIAL OF RUBBER GROWING SOILS IN NORTH - EAST INDIA

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Studies on potassium (K) release potential of rubber growing soils in three states of North-East (NE) India namely Assam, Meghalaya and Tripura was carried out. Results revealed that rubber growing soils of Meghalaya could supply K to plant at a higher rate than the other two States of NE India as indicated by its higher K releasing parameters *viz.* constant rate K (1.38 mg100g^{-1}), step K (101.8 mg100g^{-1}) and cumulative K release potential (113.4 mg100g^{-1}). Rubber growing soils of Tripura with high content of low active kaolinite clay recorded lower values of various K releasing parameters *vis-à-vis* low plant available K. Significant positive relationship of silt, clay and silt+ clay with K release parameters suggested that finer fractions of soil played an important role in K release. Step K and constant rate K showed positive and significant relationship with exchangeable and non-exchangeable K, whereas, cumulative K showed significant relationship with non-exchangeable pool of K only. Data indicated that K releasing power of soils is the sum of exchangeable and non-exchangeable form of soil K and long term availability of soil K to plants depends mainly upon its non-exchangeable pool. Total K ranged from 0.67 to 1.51 per cent and did not record significant relationship with K releasing parameters indicating that the major share of mineral K is not available for plant uptake. Results also suggested that K supplying power under rubber growing soils of Meghalaya may exhaust quickly due to its higher K releasing parameters which necessitates constant monitoring of K fertility status of these soils.

Keywords: NE India, Potassium-release potential, Potassium availability, Rubber growing soils, Soil properties.

Potassium (K) is one of the essential plant nutrients which play a major role in plant metabolism, growth and yield. It improves the water use efficiency, provides resistance to cold stress, lodging and diseases to plants. Therefore, nutrient supply to plant particularly K need to be monitored continuously in view of the crop needs and the capacity of soils to fulfill such needs (Baruah, 2002). Potassium content of a given soil is largely controlled by the mineralogical make up of soil, as greater proportion of total K is present as an integral part of the crystal structure of various silicate minerals. Again, the rate and amount of K being released from soil are important factors in determining the K status of a given soil.

In rubber plantation, the harvested crop is hydrocarbon, therefore, it was assumed that mineral demand for rubber should be

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small. Later on, increase in yield potential of crop, depletion of K from soil matrix and better understanding of the plant nutrient requirements, have made K fertilization as an established management practices for rubber (Pushpadas, 1974; Punnoose *et al.*, 1978). In India, traditionally, rubber cultivation is confined to southern States, predominantly in Kerala. Later, due to increased demand of natural rubber, its cultivation is extended to north-eastern States of India. In general, rubber growing soils of these states are red in colour and belong to Ultisol or Alfisol. They are deep, highly weathered, well drained and poor in fertility status and sandy loam or sandy clay loam in texture (Bhattacharya *et al.*, 1996). These soils contain higher amount of exchangeable magnesium (Mg) which holds an antagonistic effect with K thereby restricting its availability to plants (Yogaratnam *et al.*, 1984). Besides some abiotic and biotic factors, low yield of rubber in this region could be attributed to poor soil fertility particularly K (Singh *et al.*, 2006). Negative K balance under rubber plantation in this region calls for judicious K fertilization in these soils (Mandal *et al.*, 2011). 1*N* ammonium acetate (NH_4OAc) extractable K from a given soil is considered as an index for plant available K and based on this value, fertilizer requirement for rubber is calculated (Karthikakuttyamma *et al.*, 2000). However, it has been reported that non-exchangeable K also plays an important role for plant nutrition. Therefore, current research interest in K fertility studies has switched to non-exchangeable K instead of measuring exchangeable K alone (Srinivasarao *et al.*, 2001). In addition to that, determination of the rate at which K is being supplied to soil-solution from soil-matrix during crop growth period also caught the attention of many workers (Nath and Purkayastha, 1988; Baruah *et al.*, 1996; Srinivasarao *et al.*, 1998; Singh and Biswas, 2008).

Haylock (1956) proposed a method of measuring step K and constant rate K (CR-K) to assess the long-term K supplying power of a given soil. While step K gives an idea of plant utilizable non-exchangeable K, constant rate K gives an idea about K release potential of soil from its mineral pool. Hence, studies on soil reserve K and its release pattern are important for predicting K availability to plants. In the present paper, we examine the K release characteristics of some potential rubber growing soils in NE India with a view to formulating K fertilization for rubber plantation of this region.

Fifty four composite soil samples (0-30 cm depth) under mature rubber plantation (10-25 years old plantation) were collected, eighteen each from the state of Assam (Goalpara, Kamrup and Kokrajhar), Meghalaya (East and West Garo Hills) and Tripura (North, South and West Tripura). The soil samples were air dried, sieved through 2 mm sieve and kept in polythene bags for detailed analysis. All the samples were subjected to mechanical analysis for determining their texture. Fertility status of these soils were assessed as per the standard procedure (Jackson,1973). Exchangeable K was determined by leaching the soil samples with 1*N* NH_4OAc. Non-exchangeable K was estimated by boiling with 1*N* HNO_3, whereas, total K from soil was determined by HF-$HClO_4$ method. Kinetics of K release from a given soil was determined by the procedure formulated by Haylock (1956) where long-term K supplying power of a given soil was determined using 1N HNO_3 as an extractant and K release from a given soil by repeated extraction with 1N HNO_3. Constant K was taken at a stage where similar amount of K is extracted in consecutive extractions whereas step K was computed by subtracting the constant rate K values from the K extracted in each extraction and by summation of all these values. The total amount of K released in all the extractions was taken as cumulative K. Simple correlation among the different forms of K with soil properties was obtained (Gomez and Gomez, 1997).

We have confined our study to the surface soil (0-30 cm) under mature rubber plantations as most of the feeder roots of rubber are concentrated in the surface layer. Data pertaining to soil properties under rubber plantation from the study area showed that they were predominantly acidic in reaction with soil pH values ranging from 3.91 to 4.96. Surface soils of Tripura showed lower pH values than the other two locations which could be attributed to higher leaching loss of cations or presence of higher sesquoxides. Organic carbon (OC) content of these soils varied from 0.33 to 1.75 per cent. In general, the rubber growing soils in Garo Hills of Meghalaya recorded higher percentage of OC (1.37%) followed by Assam (1.14%) and Tripura (0.95%). In all these soils, available P was very low (<1mg100g^{-1}) while available K was low to medium (3.1 to 23.8 mg100g^{-1}). Available Ca and Mg in the rubber growing soils of NE region are high (Krishnakumar and Potty, 1989). Cation exchange capacity (CEC) ranged from 4.6-18.5 with a mean value of 10.6 c mol (p$^+$) kg^{-1} indicating poor nutrient reserve in these soils. Among the three States, rubber growing soils of Tripura showed low values of CEC which could be due to the presence of higher amount of low active kaolinite clay in soil matrix (Bhattacharya *et al.*, 1996).

Texture of these soils ranged from sandy clay to clay loam (Table 1). They were low in exchangeable bases (3.2 cmol (p$^+$) kg^{-1}) and base saturation (41.9%). Soils of Assam and Tripura were mostly sandy clay loam or sandy loam or clay loam in texture whereas, soils of Meghalaya ranged from silty clay loam to sandy clay loam. Exchangeable bases (cmol (p+)/kg) were higher in Meghalaya (3.54) than Assam (3.1) and Tripura (2.7). Base saturation (%) of rubber growing soils in Meghalaya were higher (46.1) than Assam (41.8) and Tripura (37.8). Studies on different fractions of soil K from these places showed that exchangeable K varied from 62 to 96 ppm and non-exchangeable K ranged from 412 to 639 ppm. Total K content of these soils varied from 0.67 to 1.51 per cent. The results showed that rubber growing soils of Meghalaya recorded high K status compared to the other two States.

Data pertaining to K release potential of soils under rubber plantation from these three locations are presented in Fig. 1-5. In Assam, CR-K ranged from 0.4 to 2.2 mg

Table 1. **Surface soil (0-30 cm) properties of mature rubber plantation in the NE India**

Location	Sand	Silt (%)	Clay	Texture	Ex. Bases (c mol (p+)kg^{-1})	BS (%)	Ex. K (ppm)	Non-ex.K	Total K (%)
Assam	44-56	18-27	19-29	scl - cl	3.0-3.6	38-48	26-172	225-768	0.52-1.54
	(49.7)	(22.9)			(3.1)	(42)	(76)	(456)	(0.83)
Meghalaya	37-53	17-33	20-30	sicl - cl	2.9-3.9	41-55	31-228	350-886	1.1- 2.1
	(44.7)	(26.4)	(29.6)		(3.54)	(46)	(96)	(638)	(1.5)
Tripura	43-61	12-25	18-26	scl - sl	2.6-3.2	34-46	22-145	201-724	0.45-1.25
	(54.7)	(19.8)	(25.2)		(2.7)	(37.8)	(62)	(412)	(0.67)

Mean values are given In parenthesis; cl = clay loam, sicl= silty clay loam, scl= sandy clay loam, sl= sandy loam

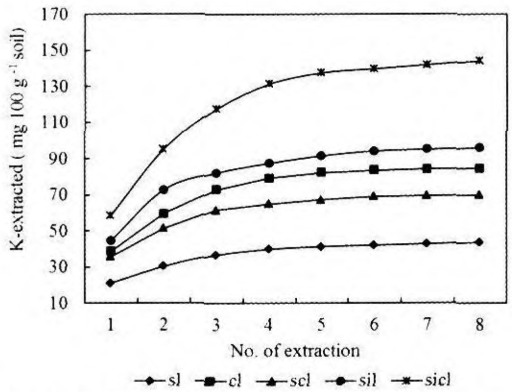

Fig. 1. Cumulative K release from rubber growing soils of Assam

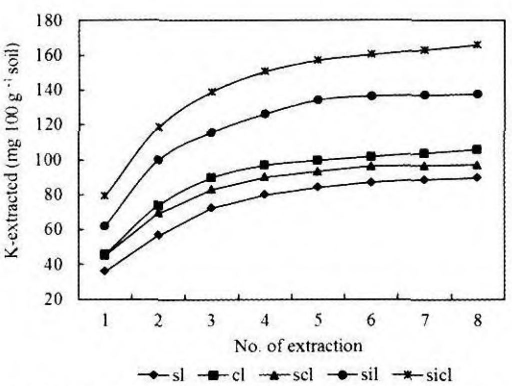

Fig. 2. Cumulative K release from rubber growing soils of Meghalaya

$100g^{-1}$ of soil with a mean value of 0.96 and step K varied from 38.5 to 128.8 $mg100g^{-1}$ of soil with a mean value of 77.1. Cumulative K release potential of soils ranged from 44.1 to 146.4 mg $100g^{-1}$ of soil with a mean value of 91.8. Cumulative K release potential from texturally different soils under rubber showed (Fig. 1) a clear distinctive trend among them. Highest cumulative K release was obtained from silty clay loam (144.2 $mg100g^{-1}$) whereas minimum was under sandy loam soil (43.4 mg $100g^{-1}$). At the beginning, K release potential of the three textural groups *viz.* silty loam, clay loam and sandy clay loam showed a similar pattern. However higher K release was observed under silty loam soil which could be attributed to its higher content of non-exchangeable pool of K.

In Meghalaya, step K ranged from 63.7 to 146.3 mg $100g^{-1}$ of soil with a mean value of 101.8. Constant rate K (CR-K) ranged from 0.5 to 2.8 $mg100g^{-1}$of soil with a mean value of 1.38 whereas, cumulative release of K varied from 76.5 to 168.5 $mg100g^{-1}$ with a mean value of 113.4. Wide variations in CR-K were observed in rubber growing soils of Meghalaya and it was highest in silty clay loam soil (2.8) and lowest in clay loam soil (0.5). Higher values for CR-K could be attributed to presence of higher amount of K-bearing minerals in these soils (Mandal and Baruah, 2011). The degraded illite and fixed K due to interstratifications can release higher amount of K in soil solution under favorable condition. That is why these soils showed higher cumulative K release values (Fig. 2). Cumulative K release was high for silty clay loam soil (168.5 $mg100g^{-1}$) and low for sandy loam soil (76.5 mg/100 g). Cumulative K release under five different textured soils (Fig. 2) showed that silty clay loam and silty loam soils released higher amount of K whereas K release potential of soils under sandy loam, sandy clay loam and clay loam were low to moderate. The reason may be due to higher K bearing minerals in finer fractions of soil.

In Tripura, step K ranged from 38.2 to 106.5 $mg100g^{-1}$ of soil with a mean value of 71.6. Silty loam soils registered highest values for step K (106.5) and sandy loam soils registered lowest values (38.2). Silty clay loam soil showed highest (1.3) and sandy loam soil the lowest (0.3) CR-K. Cumulative K release ranged from 41.4 to 120.5 mg $100g^{-1}$ of soil. Highest K release potential was found under silty loam soil

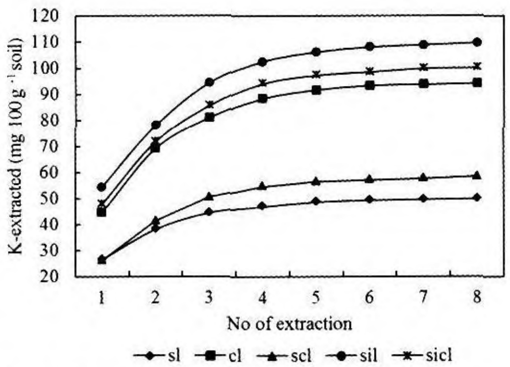

Fig. 3. Cumulative K release from rubber growing soils of Tripura

(120.5 mg $100g^{-1}$ of soil) and lowest in sandy loam soil (41.4). Silty loam, silty clay loam and clay loam soil could release higher amount of K due to the presence of hydroxyl-interlayered vermiculite minerals (Fig. 3) while sandy clay loam and sandy loam soils had low K release potential due to the presence of higher proportion of sand in these soils.

Comparison of mean K releasing parameters of soils under rubber of the three locations (Fig. 4 and 5) revealed that rubber growing soils of Meghalaya supplied K to soil solution at a higher rate than other two locations as indicated by its higher K releasing parameters which might be due to its association of higher levels of K bearing minerals and release of K from its non-exchangeable pool. The soils of Tripura had higher amount of low active kaolinite clay as dominant mineral (Bhattacharya *et al.* 1996). As a result, these soils showed lesser values in various K releasing parameters compared to the soils from other two states. In general, K supplying capacity of soils of NE region follows the order: Meghalaya> Assam > Tripura. The sequence of cumulative K-release extracted by *1N* HNO_3 as well as step K within the soil texture follows the same manner as sandy loam < sandy clay loam < clay loam < silty loam < silty clay loam. Similar observations were also recorded by Baruah *et al.* (1990); Majumder and Data (1999); Singh and Biswas (2008).

Correlation studies between K release parameters and important soil properties are presented in Table 2. Sand showed significant negative correlation with all the K release parameters indicating coarser fraction of soils had little role in K release potential of soils under rubber. Significant positive relationship of silt, clay and silt+ clay with K release parameters of soil

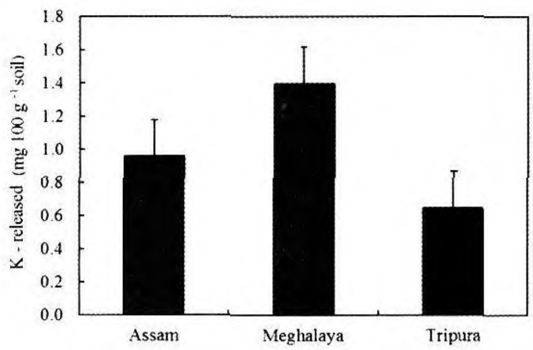

Fig. 4. Mean constant rate release for soil K under rubber growing soils of NE India

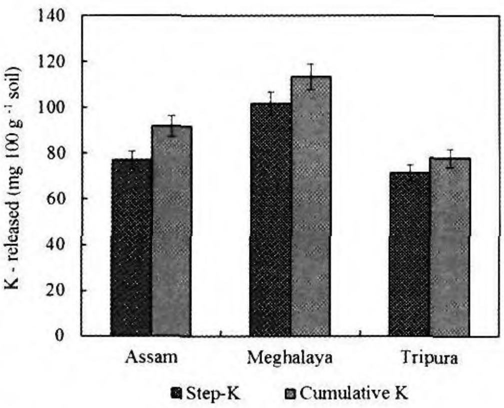

Fig. 5. Mean K releasing parameters under rubber growing soils of NE India

Table 2. **Correlation between K-release parameters and selected soil properties**

K release parameters	Sand	Silt	Clay	Silt+clay	Ex. K	Non-ex K	Total K
Step K	-0.48*	0.52*	0.55*	0.61*	0.50*	0.54*	0.23
Constant rate K	-0.45*	0.54*	0.51*	0.66**	0.53*	0.58*	0.22
Cumulative K	-0.53*	0.63*	0.64*	0.75**	0.28	0.75**	0.30

* significant at 5% level ** significant at 1% level

suggested that finer fractions of soil played an important role on K release as it offers more surface area to be extracted. Both exchangeable and non-exchangeable K showed positive and significant relationship with step K and constant K but cumulative K showed significant relationship only with non-exchangeable pool of K. Data indicated that K releasing power of soils was the sum of exchangeable and non-exchangeable K of soils. Total K content of soil alone was positively correlated with all the K releasing parameters of soil. Therefore, it was felt that a substantial amount of mineral K is unavailable for plant uptake in these soils or the present extracant (1N NH_4OAc) was unable to determine the actual K releasing power of rubber growing soils of NE region. It was also observed that the amount of K obtained with the initial extractantion of 1N HNO_3 was higher than the succeeding extracants. This may be due to occurrence of different types of exchange sites in the clay minerals *viz.* planar surface and the broken edge sites of crystal lattice, which could release K quickly at the beginning but stabilized over time. Pal *et al.* (1992) also reported that K supplying power of soil was influenced by mineralogical make up of a given soil. In the present study, it was observed that degraded and withered illite in Meghalaya (Mandal and Baruah, 2011) could release a substantial amount of K at the initial years but its release power may decrease substantially over the years. From the constant rate K values, it was observed that soils under Meghalaya released K at a much faster rate compared to soils from other two states. Therefore, plant available K under rubber soils of Meghalaya may be exhausted much quicker than the soils from other two states which calls for constant monitoring of K status of these soils.

Studies on K release kinetics in rubber growing soils of NE region revealed that the soils of Meghalaya could supply K to plant at a higher rate than those of Assam and Tripura. The study also revealed that K supplying power of Meghalaya soils may exhaust quickly due to its higher K releasing parameters which necessitates the constant monitoring of K fertility status of these soils.

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