ABSTRACT

Characterization of Rubber Growing Soils of North East (NE) India in Relation to Potassium Dynamics

In North Eastern part of India, rubber plantation is now gainfully cultivated. This has given a moral boost to the economy of the marginal people particularly tribal community. About 4.5 lakh hectares of land in NE region could be brought under rubber cultivation. However, productivity of this soil is relatively low (1000 kg/ha) compared to national average (1700 kg/ha). One of the reason might be due to acidic nature of soil vis-à-vis poor nutrient availability. Therefore, a good management practices for rubber has to be envisaged for sustained growth and yield.

In NE Region, soil and environment degradation is a big problem. This is further aggravated due to ecologically unsuitable shifting cultivation, though the local tribes/indigenous people are socio-culturally very much attached with this form of land use. The shifting cultivation is usually preceded by burning the organic debris. As a result organic matter content of the soils is decreased; beneficial microorganisms are reduced and soils are degenerated. As a result, jhuming is no more economical. Hence, efforts are there to wean away the shifting cultivators from this practice by various government agencies through various welfare schemes. Though the forest soils are rich in organic matter (OM) but soils of humid sub-tropical region especially Tripura and other foot hills of NE-region are highly deficient in OM, available P and K. About 95% of the soils are acidic which could be attributed to higher leaching loss of essential bases. As a result, fertility status of these soils is poor. Besides water, soil fertility probably is the single most important edaphic factor producing good crops and yield. Therefore, it is paramount important to know the physico-chemical and fertility status of any given soil for adopting better management practices to get sustainable crop yield.

Potassium (K) is one of the major and essential plant nutrients which also plays a major role in plant metabolism, growth and yield. K is reported to activate more than sixty enzymes in plant and involved in several biosynthetic processes, such as CO₂ assimilation, photo phosphorylation, ATP synthesis etc. It also improves the water use efficiency, provides resistance to cold stress, lodging and disease to plants. Therefore, nutrient supply to plant
particularly K has to be monitored continuously in view of the crop needs and the capacity of soils to fulfill such needs. 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 such as K-feldspars, muscovite mica, biotite mica, illite and inter stratified minerals (hydroxy-interlayered-vermiculites). The content of K bearing minerals, rate and amount of K released from soil are important in determining the K status of soils. Information about mineralogy of soil K are, therefore, of much relevance for assessing long range availability of this essential plant nutrient. The sufficiency or deficiency of plant available K in soils suggests the importance of relationship between K uptake by plants, physico-chemical and mineralogical make up of soil and dynamic relationship of various pools of K.

However, not much information about the physico-chemical and mineralogical properties of potential rubber growing soils of NE Region vis-a-vis K-dynamics are available for efficient nutrient management. Therefore, the present work was undertaken with the following objectives:

**Objective:**

I. To make a general survey on soil potassium (K) status of potential rubber growing soils of NE-region as well as to assess nutrient dynamics in relation to spatial and temporal variation of soils

II. To establish Quantity-Intensity (Q/I) relationship of soil K and to relate the Q/I parameters with soil properties

III. To investigate kinetics of non-exchangeable K release from some benchmark soils under mature rubber plantation and to study their K fixation behavior

IV. To evaluate suitable extractant(s) for assessment of plant available K for rubber growing soils

V. To study the effect K-fertilization on growth of rubber plants and to work out K-balance under rubber soils

This thesis consists of five chapters, *viz*, (i) Introduction, (ii) Study area (iii) Materials and methods, (iv) Results and Discussion and (v) Conclusions.
Chapter 1. In this chapter, soil characteristics namely, physico-chemical properties, acidity components, nutrient availability, various forms of soil K and their release kinetics are reviewed. The importance of physical and chemical properties under rubber soils both traditional and non-traditional (NE-region) is described. Potassium nutrition to rubber is comprehensively documented.

Chapter 2. In this chapter, a general description of the study area distributed in three states namely Assam (Barak valley districts and Lower Brahmaputra valley districts), Meghalaya (East and West Garo Hill districts) and Tripura (West, South and North districts) of NE region is given. Aims and objectives of the present investigation find place in this chapter. Climate, rainfall and land use pattern are also described here.

Chapter 3. Various methods adopted for the analysis of soils in the field and laboratory are described in brief in this chapter along with the sample collection and locations of the selected sampling sites.

Chapter 4. Results of the analysis of soils under rubber from three potential rubber growing states in NE Region are discussed in detail in this chapter. Data are given in tabular form along with minimum, maximum, standard deviation with diagrammatic presentation for kinetic, Q-I relation, XRD data etc. Step regression equations are developed to establish the interrelationship between different properties of soils and forms of potassium. The rubber growing soils are acidic in reaction with pH values varying from 4.12 – 6.01 in surface soil and 4.27 –6.04 in subsurface soil. Surface soils showed lower pH than subsurface soil which may be due to higher organic carbon (OC) content in upper layer of soils. The OC content of these soils varied from 0.18 to 3.57 % in surface soil and 0.2 to 1.28 % in subsurface soil; soils under Garo hills of Meghalaya contained higher percentage of OC (with a mean value of 1.37 %) followed by Assam (1.14%) and Tripura (0.95%). Texture of rubber soils are predominantly sandy loam, sandy clay loam and clay loam. CEC and base saturation of these soils are relatively low with mean values of 8.9 cmol (p+)kg⁻¹ and 32.3% respectively, indicating poor nutrient reserve. Available phosphorus in acid soils is always a limiting factor for crop growth and rubber soils are also no exception. It is also observed that 44% rubber soils in Tripura was found deficient in available potassium, whereas only 7 % soils above the critical range. The rubber growing soils of Assam showed that only 28 % soils was low in plant available K;
whereas 14% soils was above sufficiency level. In case of Meghalaya only 10% soils was seen under deficiency level and 15% soils above sufficiency level. Surface soils contained higher percentage of sand and its value decreased with depth in all the soils. On the contrary, clay content increased with depth. Available nitrogen of these soils ranged from 141.6 – 410.2 kg/ha, with a mean value of 272.7 kg/ha indicating low to medium status for available nitrogen. Similarly available P₂O₅ and K₂O ranged from 2.5 – 32.9 and 88.2 – 452.6 kg/ha, respectively, suggesting poor status for phosphorus and low to medium status for potassium. Data on available NPK content of soils revealed that at low soil pH, availability of these nutrients was reduced in comparison to relatively higher soil pH. In all the rubber growing soils, water soluble – K and exchangeable K were found to be higher in surface soil with a mean value of 12.9 and 67.4 mg/kg, respectively, which decreased with depths. However, non-exchangeable (mean value = 476.1 mg/kg) and total K (mean value = 0.78%) content of soils increased with depth. In subsurface soil, K-containing mineral was relatively rich which might have improved the non-exchangeable and total pool of K. Of the soil size fractions, clay and silt fractions of soil contained higher amount of potassium than that of sand. Both clay and silt fractions of soils are relatively rich in K-minerals (mica, feldspar, interstratified minerals). By and large, all the soils showed an increasing trend on K-fixation with increasing levels of applied K. However, the percent of K-fixation tended to decrease gradually with increasing levels of applied K. Data also revealed that rubber soils under Meghalaya fixed (42.3%) higher amount of applied K in comparison to Assam (39.2%) and Tripura (40.4%). Soils of Meghalaya also showed higher values for both labile pool (0.55) and activity ratio of K (4.24 x10⁻³) compared to other two state locations, suggesting higher availability of plant K in rubber soils under Meghalaya. Data on K-release kinetics further revealed that rubber soils of Meghalaya supplied K to plant at a higher rate compared to other two state locations as indicated by its higher K-releasing parameters in respect of step K (101.8 mg/100 gms) and cumulative- K release potential (113.4 mg/100 gms) which could be attributed to its association of higher levels of K-bearing minerals. Soils of Tripura have higher amount of kaolinites as dominant minerals in clay portion of soil which is low active. As a result such soils showed lesser values in various K-releasing parameters vis-à-vis low plant available K.
Depth wise variation in available nutrient was observed in soils under a rubber eco system. Leaching loss of N and OC from surface soil was noticed due to high rainfall and surface run off. Mobility of K down the profile was observed with the onset of monsoon and highest values were recorded after post monsoon period. The available P status in subsurface soil was not increased over time indicating its less downward mobility. Influence of graded doses of K with basal doses of N and P were tested on young rubber in a farmer’s field. Plants showed significant response towards higher doses of K fertilizer (Treatment T3 – 30 kg K/ha along with basal dose of N and P) for attaining higher girth (49.3 cm) and leaf K content of plants (1.07-1.10 %) from 4th year onwards. A decline in available K and significant increase in non-exchangeable K was recorded due to application of K-fertilizer with basal application of N & P. A gradual depletion in available K even with annual addition of K led to K imbalance in surface soils (-24 to -54 kg/ha), which calls for effective K-management programme under rubber for optimum yield and sustained soil fertility in this region.

Correlation studies among various extractants showed that Citric acid extractable K held significant relationship with ammonium acetate extractable K, H₂SO₄ extractable K and Morgan –K. Citric acid extractable K showed significant relationship with mean rubber yield (r = 0.688*) collected from all the three state locations, but only positive relationship with leaf-K. Again, 1N HNO₃ extractable K held significant relationship with leaf-K (r =0.622*), but positive relationship with mean yield of rubber. A method which can extract a substantial amount of exchangeable K together with a fraction of non-exchangeable pool of soil K would be more reliable than extracting large amount of non-exchangeable K (1N HNO₃). Based on extraction power of K and interrelationship among extractants and rubber yield, the order of extractant could be arranged as 1% Citric acid> Morgan’s reagent> 6N H₂SO₄> 1N HNO₃> 1N NH₄OAc> Water. In the light of above, it is imperative that 1% citrate soluble K may be considered as a better index for plant available K for precise fertiliser recommendation.

Chapter 5. This chapter summarizes the results obtained in the present work with conclusions and a few suggestions for further work. The thesis concludes with a complete list of references consulted and found useful to support the results of the present study with proper justification.