Geoderma xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Quantity-intensity relations of potassium in representative coastal soils of eastern India

Ranajit Panda[a,*], S.K. Patra[b]

[a] IMD, GKMS, Majhian, Uttar Banga Krishi Viswavidyalaya, West Bengal 733133, India
[b] Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741252, India

ARTICLE INFO

Keywords:
Potassium quantity-intensity isotherms
Activity ratio
Labile K^+
Potential buffering capacity
Free energy of exchange
Coastal saline soils

ABSTRACT

Quantity-intensity (Q/I) isotherms were used to evaluate the dynamics of K^+ in twelve coastal soils of eastern India. The activity ratio of K^+ (AR_e^K) and corresponding changes in labile K^+ ($\pm \Delta K$) at equilibrium increased with increasing K^+ concentrations. The equilibrium activity ratio of K^+ (AR_e^{0K}) varied between 0.09×10^{-3} and 7.50×10^{-3} $(mol\,L^{-1})^{1/2}$. The labile K^+ (K_L) ranged from 0.265 to 0.4 $cmol\,kg^{-1}$ constituting 43.8 to 204.5% of 1N NH_4OAc extractable K^+. The readily available (K_0) and fixed K^+ (K_X) varied from 0.082 to 0.290 and 0.041 to 0.278 $cmol\,kg^{-1}$ contributing 22.8 to 84.5 and 15.5 to 77.2% towards K_L, respectively. The potential buffering capacities for K^+ (PBC^K) fluctuated from 16.2 to 85.7 $cmol\,kg^{-1}(mol\,L^{-1})^{-1/2}$. The K^+ potential ranged from 2.38 to 10.76 $cmol\,kg^{-1}(mol\,L^{-1})^{-1/2}$. The free energy of K^+ exchange ($-\Delta G$) ranged from -5533 to -2906 calories mol^{-1} indicating deficient to adequate in available K^+. The AR_e^{0K}, K_0, K_X and $-\Delta G$ had significant positive correlations with pH, CEC, available and reserves soil K^+, while there were inverse relationships between PBC^K and these soil parameters. A significant positive correlation was found between AR_e^{0K} and K_0, K^+ saturation, $-\Delta G$ and significant negative correlation with K_X and PBC^K. Significant positive correlations were observed between K_X and K_L and PBC^K and significant negative correlations with AR_e^{0K}, $-\Delta G$ and K^+ saturation. PBC^K had significant negative correlations with K_0, $-\Delta G$ and K^+ saturation. The study provided useful information for understanding K^+ dynamics in coastal soils and make significant contribution to operational K^+ management.

1. Introduction

Potassium (K^+) is one of the most important macronutrients in soils which are required relatively larger amounts for plant growth. There are four different fractions of K^+ viz., solution K^+, exchangeable K^+, non-exchangeable K^+ and mineral or structural K^+ exist in soil which are in a state of dynamic equilibrium with each other (Sparks, 1987; Johnston and Goulding, 1990). Plants absorb K^+ mainly from the soil solution which is buffered by the rapidly exchangeable forms (Idigbor et al., 2009). The availability of K^+ in the soil solution, and the capacity of soil to buffer this concentration are among the important parameters that determine the effective available K^+ for plant nutrition (Raheb and Heidari, 2012; Hamed and Amin, 2017). The amount of exchangeable K^+ measured with neutral 1N NH_4OAc is widely used as a way to characterize the soil K^+ status and to predict crop K^+ requirements. Several empirical methods have been attempted to find a suitable method for determining the availability of soil K^+ to evaluate the amount of K^+ fertilizers needed by a particular crop. Potassium dynamics in relation to solution-exchange phase interactions of basic cations like K^+, Ca^{2+} and Mg^{2+} species have undergone rigorous testing for predicting the K^+ availability in different soil systems (Evangelou et al., 1994). The thermodynamic approach most often used in understanding, characterizing and evaluating the K^+ supplying capacity of soil is the quantity-intensity (Q/I) isotherm of K^+ (Beckett, 1964a, 1964b). This relationship implies that the ability of a soil system to maintain a certain concentration of a cation in solution is determined by the total amount of the cation present in readily available forms (exchangeable and soluble) and the intensity by which it is released into the soil solution (LeRoux and Summer, 1968). In the Q/I curve the equilibrium activity ratio of K^+(AR_e^K) is a measure of availability or intensity of labile K^+ in soil. Different soil exhibiting the same value of AR_e^K values may not possess the same capacity for maintaining AR_e^K when soil K^+ is depleted by plant roots (Diatta et al., 2006). Higher values of labile K^+ indicated a greater K^+ release into soil solution resulting from a larger pool of soil K^+. A high value of the potential buffering capacity for K^+(PBC^K) in soil is indicative of a good K^+

* Corresponding author.
E-mail address: ranajitpanda85@gmail.com (R. Panda).

https://doi.org/10.1016/j.geoderma.2018.07.014
Received 17 July 2017; Received in revised form 6 June 2018; Accepted 8 July 2018
0016-7061/

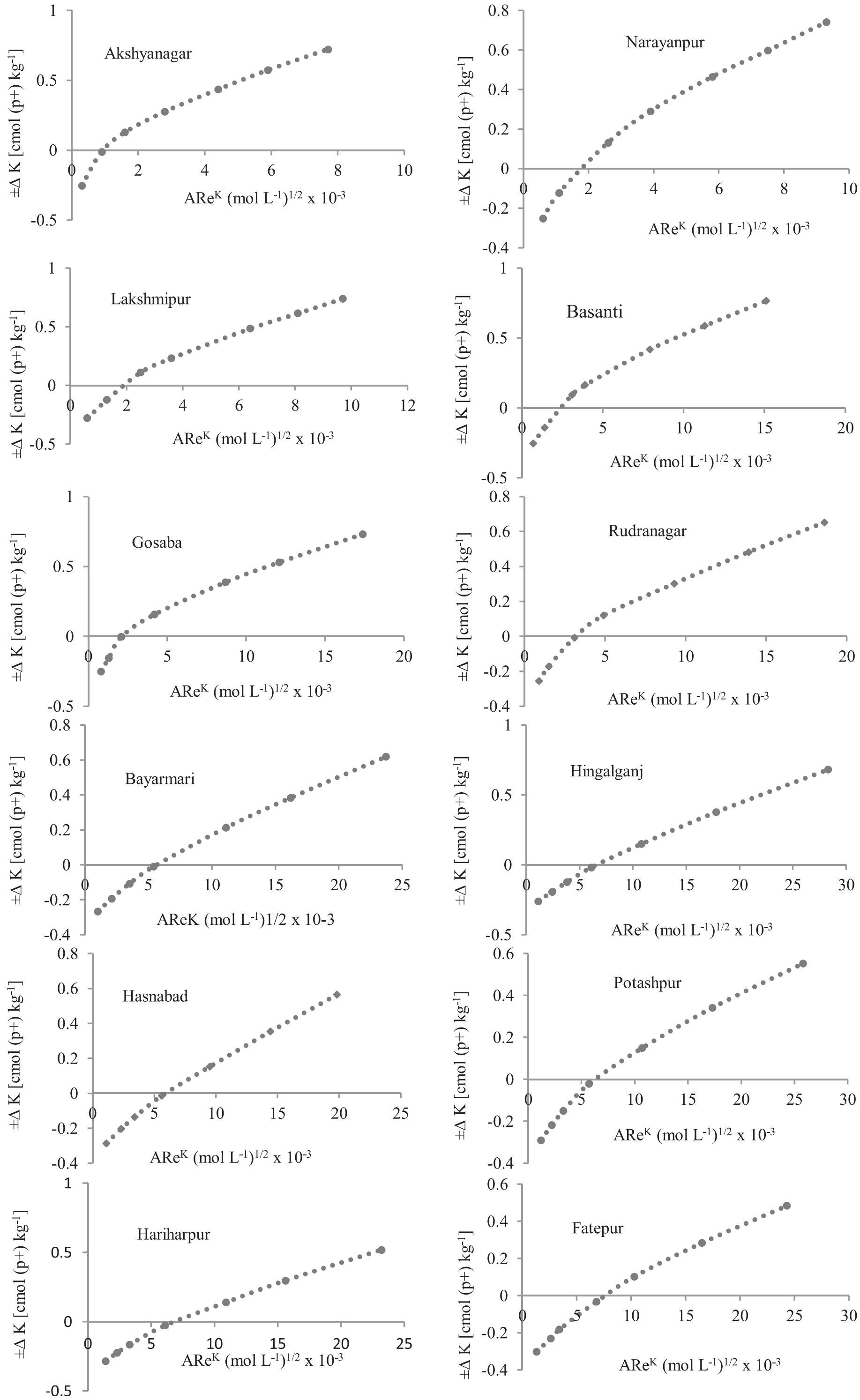

Fig. 1. Quantity-intensity curves of potassium for the selected coastal saline soils.

availability while a low PBC^K value would suggest a need for K^+ fertilization (Wang et al., 2004).

Numerous studies have been conducted extensively to assess the availability of K^+ in soils using Q/I concept or soil K^+ buffering characteristics (Bandyopadhyay et al., 1985; Pal and Subba Rao, 1997; Dhillon and Parischa, 2000; Niranjana et al., 2000; Samadi, 2006; Patra et al., 2007; Abaslou and Abtahi, 2008; Yawson et al., 2011; Bahmni et al., 2013; Lalitha and Dhakshinamoorthy, 2015). Such information in the salt affected coastal soils of eastern India is limited. In this perspective, the present investigation was carried out with the objectives of evaluating the potential capacity of selected coastal soils for K^+ supply and replenishment by characterizing the K^+ quantity-intensity (Q/I) concept and its relationship with some relevant soil properties.